CORNELL UNIVERSITY LIBRARY
3 1924 050 814 692

DATE DUE

GAYLORD PRINTED IN U.S.A.

ALBERT R. MANN
LIBRARY
AT
CORNELL UNIVERSITY

QK
600
M992
v.42
1991

K
90
992
.42
991

MYCOTAXON

AN INTERNATIONAL JOURNAL DESIGNED TO EXPEDITE PUBLICATION
OF RESEARCH ON TAXONOMY & NOMENCLATURE OF FUNGI & LICHENS

Vol. XLII October-December 1991

CONTENTS

Pythium mycoparasiticum sp. nov., an aggressive mycoparasite from British soils.
J. W. Deacon, S. A. K. Laing and L. A. Berry 1
Glomus mortonii sp. nov., a previously undescribed species in the Glomaceae isolated from the Tallgrass Prairie in Kansas.
Stephen P. Bentivenga and B. A. D. Hetrick 9
New records of Myxomycetes from Mexico. .... **L. Hernández-Cuevas, M. Rodríguez-Palma, G. Galindo-Flores and A. Estrada-Torres** 17
A new species of *Phanerochaete* (Aphyllophorales, Corticiaceae) from India.
A. B. De 29
The new southern hemisphere lichen genus *Coelopogon* (Lecanorales, Ascomycotina), with a new species from Southern Africa.
Franklin A. Brusse and Ingvar Kärnefelt 35
A nomenclatural synopsis of *Septosperma* (Chytridiomycetes) and emendation of *S. rhizophydii*. .... **Will H. Blackwell and Martha J. Powell** 43
Notes on Coelomycetes. IV. *Phyllosticta andropogonivora*, causal organism of leafspot disease of *Schizachyrium scoparium* (Little Bluestem) and *Andropogon gerardii* (Big and Sand Bluestem), reclassified in *Ascochyta*.
Gareth Morgan-Jones, Michele R. Owsley and Joseph M. Krupinsky 53
Fungi of *Yucca baccata*. 1. *Piptarthron pluriloculare* and its teleomorph, *Planistroma yuccigena*. .... **Annette Ramaley** 63
"Lecanora" opiniconensis: a placodioid member of the Parmeliaceae (lichenized Ascomycotina). .... **H. Thorsten Lumbsch, Kerstin E. Schmitz and G. Benno Feige** 77
Dematiaceous hyphomycetes on *Freycinetia* (Pandanaceae). 3. *Chalarodes* gen. nov. .... **E. H. C. McKenzie** 89
Capitorostrum cocoes sp. nov., causing leaf spot of *Cocos nucifera*.
Kevin D. Hyde and Elijah Philemon 95
A phylogeny of fissitunicate ascostromatic fungi. .... **Don R. Reynolds** 99

[Contents continued overleaf]

ISSN 0093-4666 MYXNAE 42:1-532 (1991)

Published quarterly by MYCOTAXON, LTD., P. O. Box 264, Ithaca, NY 14851.
For subscription details, availability in microfilm and microfiche, and availability of articles as tear sheets, see back cover.

[Contents continued from front cover]

Meliolaceae of South India - X. . . . . **V. B. Hosagoudar and R. D. Goos** 125
Athelopsis instead of *Pteridomycetes* (Corticiaceae, Basidiomycetes). **Kurt Hjortstam** 149
Morphology, cytology and taxonomy of *Hydnotrya cerebriformis* (Pezizales). **Bin-Cheng Zhang** 155
A new species in the lichen genus *Parmelia* (Parmeliaceae, Ascomycotina), from the Blouberg, Northern Transvaal, South Africa, with further notes on southern Africa lichens. . . . . **Franklin A. Brusse** 163
Genotypic patterns of some Italian populations of the *Tuber aestivum-T. mesentericum* complex. . . **Giovanni Pacioni and Giancarla Pomponi** 171
Marasmiellus dunensis (Marasmiaceae, Agaricales), a new species from the European Mediterranean. . . . . **G. Robich, G. Moreno and R. Pöder** 181
A new species of *Hemimycena* (Agaricales, Tricholomataceae) from Anza Borrego Desert of Southern California. . . . . **Dennis E. Desjardin** 187
Nannizziopsis (Ascomycotina) and related genera. **J. Guarro, J. Cano, and Ch. de Vroey** 193
Hypogeous fungi from peninsular Spain. II. **G. Moreno, R. Galán and A. Montecchi** 201
A new species of *Phialomyces*.. . . . **Rafael F. Castañeda Ruiz and W. Gams** 239
Nomenclatural remarks on the lichens *Heppia solorinoides, Peltula obscurans* and *P. placodizans.* **Burkhard Büdel, José Maria Egea and H. Thorsten Lumbsch** 245
Anamylopsora, a new genus in the Lecideaceae. . . . . **Einar Timdal** 249
An indigenous species of *Leccinum* (Boletaceae) from Australia. **N. L. Bougher and H. D. Thiers** 255
On lichenicolous fungi from continental North America. **D. Triebel, G. Rambold and T. H. Nash III** 263
Pure culture studies on *Volucrispora graminea* and *Isthmotricladia britannica* (Hyphomycetes). . . . . **A. Roldan** 297
Studies in the genus *Cladosporium* sensu lato. V. Concerning the type species *Cladosporium herbarum*.. .**John M. McKemy and Gareth Morgan-Jones** 307
Miscellaneous notes on Indian Cercosporeae. **G. Bagyanarayana and P. Jagadeeswar** 319
New combinations and new synonyms in the genus *Claussenomyces.* **Teresita Iturriaga** 327
Alpine and subalpine fungi of the Cascade and Olympic Mountains. 2.*Macowanites lymanensis* sp. nov. **Efren Cazares and James M. Trappe** 333
Alpine and subalpine fungi of the Cascade and Olympic Mountains. 3.*Gastroboletus ruber* comb. nov. . **Efren Cazares and James M. Trappe** 339
A new foliicolous species in the lichen genus *Porina* (Porinaceae, Pyrenulales) from southern Africa. . . . . **Franklin A. Brusse and Colin H. Dickinson** 347
Buergenerula zelandica sp. nov. on *Carex spp.* in New Zealand. **E. H. C. McKenzie** 351
Pairing tests with species of Aphyllophorales (Basidiomycetes) from two phytogeographically isloated areas.. . . . . **Nils Hallenberg** 355
Description and identification of cultures of ectomycorrhizal fungi found in North America. . . . . **Leonard J. Hutchison** 387

[Contents continued on inside back cover]

MYCOTAXON

AN INTERNATIONAL JOURNAL DESIGNED TO EXPEDITE PUBLICATION
OF RESEARCH ON TAXONOMY & NOMENCLATURE OF FUNGI & LICHENS

ALBERT R. MANN
LIBRARY
JAN 09 1992
ITHACA, NY 14853

VOLUME XLII, 1991

COMPLETE IN ONE VOLUME

CONSISTING OF iv + 532 PAGES INCLUDING FIGURES

EDITOR-IN-CHIEF

JEAN BOISE CARGILL

Harvard University Herbaria
22 Divinity Avenue, Cambridge, MA 02138, USA

ASSOCIATE EDITORS

LINDA M. KOHN

Book Review Editor

Botany Department, University of Toronto – Erindale
Mississauga, Ontario L5L 1C6, Canada

GRÉGOIRE L. HENNEBERT

French Language Editor

Laboratoire de Mycologie systématique et appliquée
Université Catholique de Louvain, B-1348 Louvain-la-Neuve, Belgium

ROBERT DIRIG

Index Editor

Bailey Hortorium, Mann Library Building
Cornell University, Ithaca, NY 14853, USA

EDITORIAL ADVISORY BOARD

OVE E. ERIKSSON, Umeå, Sweden (1990-93)
GRÉGOIRE L. HENNEBERT, Louvain-la-Neuve, Belgium (1990-96)
JAMES W. KIMBROUGH, Gainesville, Florida (1990-91, *Chm.*)
RONALD H. PETERSEN, Knoxville, Tennessee (1990-94)
JACK D. ROGERS, Pullman, Washington (1990-92)
AMY Y. ROSSMAN, Beltsville, Maryland (1990-95)

Published by

MYCOTAXON, LTD., P.O. BOX 264
ITHACA, NY 14851-0264, USA

Printed in the United States of America

Table of Contents, Volume Forty-Two

Pythium mycoparasiticum sp. nov., an aggressive mycoparasite from British soils.
J. W. Deacon, S. A. K. Laing and L. A. Berry 1

Glomus mortonii sp. nov., a previously undescribed species in the Glomaceae isolated from the Tallgrass Prairie in Kansas.
Stephen P. Bentivenga and B. A. D. Hetrick 9

New records of Myxomycetes from Mexico. .... **L. Hernández-Cuevas, M. Rodríguez-Palma, G. Galindo-Flores and A. Estrada-Torres** 17

A new species of *Phanerochaete* (Aphyllophorales, Corticiaceae) from India.
A. B. De 29

The new southern hemisphere lichen genus *Coelopogon* (Lecanorales, Ascomycotina), with a new species from Southern Africa.
Franklin A. Brusse and Ingvar Kärnefelt 35

A nomenclatural synopsis of *Septosperma* (Chytridiomycetes) and emendation of *S. rhizophydii*. .... **Will H. Blackwell and Martha J. Powell** 43

Notes on Coelomycetes. IV. *Phyllosticta andropogonivora*, causal organism of leafspot disease of *Schizachyrium scoparium* (Little Bluestem) and *Andropogon gerardii* (Big and Sand Bluestem), reclassified in *Ascochyta*.
Gareth Morgan-Jones, Michele R. Owsley and Joseph M. Krupinsky 53

Fungi of *Yucca baccata*. 1. *Piptarthron pluriloculare* and its teleomorph, *Planistroma yuccigena*. .... **Annette Ramaley** 63

"Lecanora" opiniconensis: a placodioid member of the Parmeliaceae (lichenized Ascomycotina). .... **H. Thorsten Lumbsch, Kerstin E. Schmitz and G. Benno Feige** 77

Dematiaceous hyphomycetes on *Freycinetia* (Pandanaceae). 3. *Chalarodes* gen. nov. .... **E. H. C. McKenzie** 89

Capitorostrum cocoes sp. nov., causing leaf spot of *Cocos nucifera*.
Kevin D. Hyde and Elijah Philemon 95

A phylogeny of fissitunicate ascostromatic fungi. .... **Don R. Reynolds** 99

Meliolaceae of South India - X. .... **V. B. Hosagoudar and R. D. Goos** 125

Athelopsis instead of *Pteridomycetes* (Corticiaceae, Basidiomycetes).
Kurt Hjortstam 149

Morphology, cytology and taxonomy of *Hydnotrya cerebriformis* (Pezizales).
Bin-Cheng Zhang 155

A new species in the lichen genus *Parmelia* (Parmeliaceae, Ascomycotina), from the Blouberg, Northern Transvaal, South Africa, with further notes on southern Africa lichens. .... **Franklin A. Brusse** 163

Genotypic patterns of some Italian populations of the *Tuber aestivum*-*T. mesentericum* complex. .. **Giovanni Pacioni and Giancarla Pomponi** 171

Marasmiellus dunensis (Marasmiaceae, Agaricales), a new species from the European Mediterranean. .... **G. Robich, G. Moreno and R. Pöder** 181

A new species of *Hemimycena* (Agaricales, Tricholomataceae) from Anza Borrego Desert of Southern California. .... **Dennis E. Desjardin** 187

Nannizziopsis (Ascomycotina) and related genera.
J. Guarro, J. Cano, and Ch. de Vroey 193

Hypogeous fungi from peninsular Spain. II.

A new species of *Phialomyces*.. . . . **Rafael F. Castañeda Ruiz and W. Gams** 239

Nomenclatural remarks on the lichens *Heppia solorinoides, Peltula obscurans* and *P. placodizans.* **Burkhard Büdel, José Maria Egea and H. Thorsten Lumbsch** 245

Anamylopsora, a new genus in the Lecideaceae. . . . . **Einar Timdal** 249

An indigenous species of *Leccinum* (Boletaceae) from Australia. **N. L. Bougher and H. D. Thiers** 255

On lichenicolous fungi from continental North America. **D. Triebel, G. Rambold and T. H. Nash III** 263

Pure culture studies on *Volucrispora graminea* and *Isthmotricladia britannica* (Hyphomycetes). . . . . **A. Roldan** 297

Studies in the genus *Cladosporium* sensu lato. V. Concerning the type species *Cladosporium herbarum*.. .**John M. McKemy and Gareth Morgan-Jones** 307

Miscellaneous notes on Indian Cercosporeae. **G. Bagyanarayana and P. Jagadeeswar** 319

New combinations and new synonyms in the genus *Claussenomyces.* **Teresita Iturriaga** 327

Alpine and subalpine fungi of the Cascade and Olympic Mountains. 2.*Macowanites lymanensis* sp. nov. **Efren Cazares and James M. Trappe** 333

Alpine and subalpine fungi of the Cascade and Olympic Mountains. 3.*Gastroboletus ruber* comb. nov. . **Efren Cazares and James M. Trappe** 339

A new foliicolous species in the lichen genus *Porina* (Porinaceae, Pyrenulales) from southern Africa. . . . . **Franklin A. Brusse and Colin H. Dickinson** 347

Buergenerula zelandica sp. nov. on *Carex spp.* in New Zealand. **E. H. C. McKenzie** 351

Pairing tests with species of Aphyllophorales (Basidiomycetes) from two phytogeographically isloated areas.. . . . . **Nils Hallenberg** 355

Description and identification of cultures of ectomycorrhizal fungi found in North America. . . . . **Leonard J. Hutchison** 387

Book Reviews. . . . . **L. M. Kohn** 505

NOTICE: Second Regional Conference. African Mycol. Assoc.& IMA 511

Instructions to Authors 512

Author Index. 514

Index to fungous and lichen taxa. 517

Errata. 531

Reviewers. 532

Publication Date Volume 41(2). 532

MYCOTAXON

Volume XLII, pp. 1-8 October-December 1991

PYTHIUM MYCOPARASITICUM SP. NOV., AN AGGRESSIVE MYCOPARASITE FROM BRITISH SOILS

J. W. DEACON, S. A. K. LAING AND L. A. BERRY

Institute of Cell and Molecular Biology, University of Edinburgh,
Mayfield Road, Edinburgh EH9 3JH, U.K.

Pythium mycoparasiticum sp. nov. is described and compared with other *Pythium* spp., including the mycoparasites *P. acanthicum*, *P. oligandrum* and *P. nunn*.

Four mycoparasitic *Pythium* spp. have been described. *Pythium acanthicum* Drechs., *P. oligandrum* Drechs. and *P. periplocum* Drechs. (*P. periplocum sensu lato* of Dick, 1990) have echinulate oogonia and share several physiological features, including requirements for organic nitrogen and thiamine or its pyrimidine moiety (Foley & Deacon, 1986). *Pythium nunn* Lifshitz, Stanghellini & Baker (1984a) has smooth-walled oogonia, slow linear growth and it uses nitrate as sole N-source (Laing & Deacon, 1990); it is recorded from soil in the U.S.A. (Lifshitz, Sneh & Baker, 1984b; Lifshitz *et al.*, 1984c). A fifth mycoparasitic species was isolated by Deacon & Henry (1978) and provisionally identified as *P. scleroteichum* Drechs. Subsequently, Foley & Deacon (1985) detected it in several British soils, and called it *Pythium* SWO to denote its smooth-walled oogonia. We have now obtained further cultures of this fungus and we describe it as a new species, *Pythium mycoparasiticum*.

Pythium mycoparasiticum J. W. Deacon, S. A. K. Laing &
L. A. Berry sp. nov.

Hyphae principales 3-5 μm latae. Sporangia ignota. Oogonia diametro 16-23 (-28) (in medio 19.5) μm, laevia, globosa, ramos breves hypharum interdum hyphas longiores terminantia. Parietes

oogoniorum tenues, 0.5-1 μm in crassitiei. Antheridia in quoque oogonia 2-4 (-6); (6-) 7-10 (-12.5) μm longa, 4-6 μm lata; clavulata vel distincte lobata, ad oogonia insigniter et late adpressa. Hyphae antheridiferae longae, saepe ramificantes, irregulariter constrictae, oogonia involvens, plerumque exorientes uno vel plus quam uno filo myceliali, omnis filum separatem stipite oogonii (antheridia sic diclina), aliquando monoclina. Oosporae diametro 15-21 (-25) (in medio 18.3) μm, sphericae, pleroticae, laeves, parietes 1.1-2.0 (-2.5) (in medio 1.5) μm in crassitiei.

Holotypus Figs. 1, 2. Ex solo agrario, Lasswade, Scotia, Nov. 1986; coll S. A. K. Laing; **IMI** 341972.

Colonies on potato-dextrose agar slow-growing (7.2 mm radial extension 24 h^{-1} at 25°C), with faint rosette pattern, aerial mycelium absent or < 1 mm high; on sunflower seed or carrot agar faster-growing (13.5 mm radial extension 24 h^{-1} at 25°C) by surface or submerged hyphae 3-5 μm wide, with many short branches that are sometimes convoluted, of irregular width and that branch repeatedly, forming fascicles. Sporangia unknown. Oogonia 16-28 (mean 19.5) μm diameter, smooth-walled, globose, terminal on short hyphal branches, occasionally on longer hyphae; thin-walled (0.5-1.0 μm). Antheridia 2-6 (mode 3) per oogonium, (6-) 7-10 (-12.5) μm long, 4-6 μm wide, clavate or distinctly lobed, typically broadly adpressed to the oogonium; antheridial hyphae long, often branched, irregularly constricted and furrowed, enveloping the oogonium, arising from one or more branches separate from the oogonial stalk (diclinous), occasionally monoclinous. Oospores 15-25 (mean 18.3) μm diameter, spherical, plerotic, smooth-walled, yellow with age, with a wall 1.1-2.5 (mean 1.5) μm diam. and a large reserve globule (ooplast) 9-13 (mean 10.8) μm diam.

The volume of the oogonium occupied by the oospore (aplerotic index) is 82%; the volume of the oospore occupied by the oospore wall (wall index) is 42%; the volume of the oospore protoplast occupied by the ooplast (ooplast index) is 36% (means based on 20 individual oogonia).

Cardinal temperatures: minimum 6°C, optimum 22°C, maximum 30°C.

Holotype: Figs. 1, 2, based on a living culture deposited as **IMI** 341972, from arable soil , Lasswade, Scotland, Nov. 1986; collected by S. A. K. Laing.

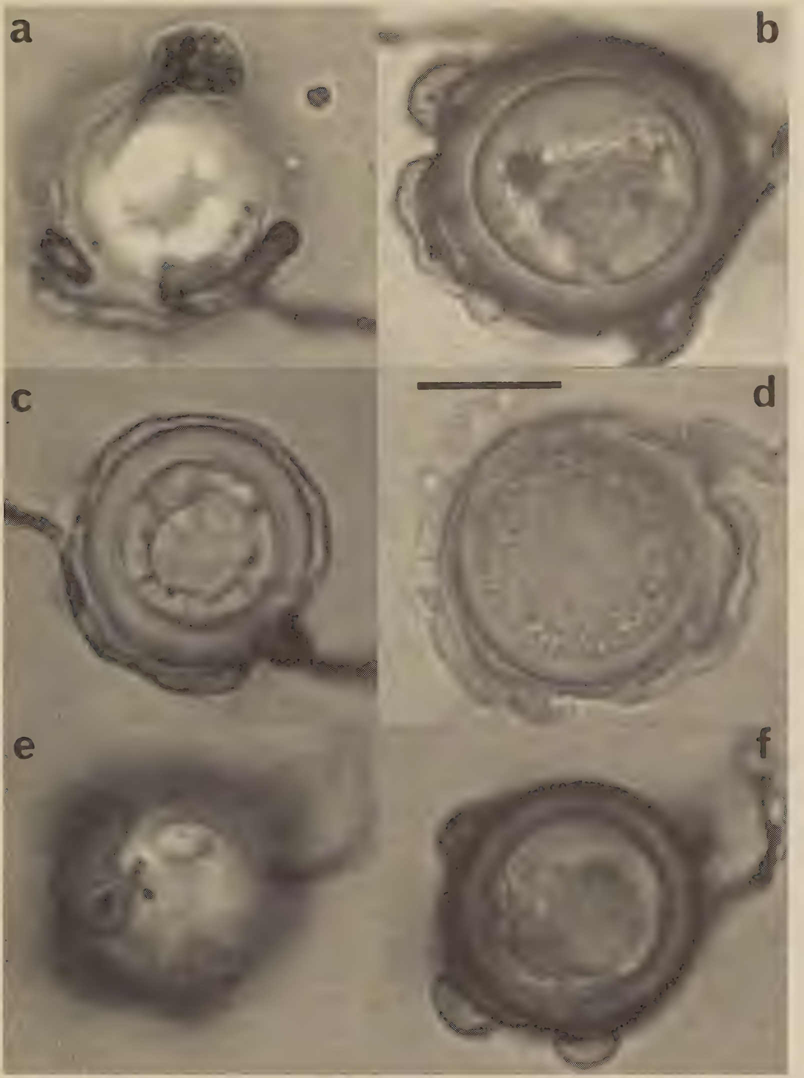


Fig. 1. *Pythium mycoparasiticum*. A-C, arrangement of antheridia on oogonia containing developing oospores, stained with cotton blue in lactophenol; D, unstained oogonium containing a mature oospore and antheridial hyphae enveloping the oogonium; E, F, a stained oogonium in two planes of focus, showing arrangement of antheridia. Bar = 10 μm

Laing & Deacon (1990, 1991) have described the aggressive mycoparasitic activities of the culture AR7A (= **IMI** 341972). Deacon & Henry (1978) and Foley & Deacon (1985, 1986) refer to cultures (not retained) similar to *P. mycoparasiticum*, termed "possibly *P. scleroteichum*" or "*Pythium* SWO".

P. mycoparasiticum has not been induced to form sporangia, but in all other respects it is typical of the genus *Pythium* which accommodates several non-sporangial species (Plaats-Niterink, 1981). The mycoparasite *P. nunn* produces hyphal swellings that resemble sporangia but have not been induced to release zoospores (Lifshitz *et al*., 1984a).

A distinctive feature of *P. mycoparasiticum* is the conspicuous envelopment of the oogonium by antheridia and antheridial hyphae that are constricted and furrowed at intervals. Except in young material, the precise arrangements of these hyphae are difficult to discern, as is the position of the septum that delimits an antheridium. In this arrangement of antheridia and antheridial hyphae *P. mycoparasiticum* resembles *P. scleroteichum*, which also grows relatively slowly, lacks sporangia and has non-echinulate oogonia (Dreschler, 1934). However, *P. mycoparasiticum* has plerotic oospores and thicker oospore walls than does *P. scleroteichum*. The sexual stage also resembles that of *P. periilum* Drechsler (1930) except for the furrowed, constricted antheridial hyphae and the typically broader contact of antheridia with the oogonium than in *P. periilum*; also *P. mycoparasiticum* is not known to produce sporangia. The reserve globule (ooplast) of *P. mycoparasiticum* is somewhat larger than in these other species and the ooplast index is larger. Shahzad, Coe & Dick (1991) have found the ooplast index to be an important distinguishing feature among *Pythium* spp.

In addition to morphological features, the mycoparasitic habit of *P. mycoparasiticum* is distinctive, and its requirements for organic nitrogen and a component of thiamine (Foley & Deacon, 1986) are useful diagnostic features, which we confirmed for the culture **IMI** 341972. The cardinal temperatures are similar to those of *P. scleroteichum* but differ from those of *P. periilum* which grows well at 34°C (Middleton, 1943). Because of its mycoparasitic behaviour and non-echinulate oogonia, *P. mycoparasiticum* superficially resembles *P. nunn*. But *P. nunn* does not have conspicuous envelopment of the oogonium by antheridial hyphae, and it uses nitrate as sole N-source - the only mycoparasitic *Pythium* sp. that does so (Laing & Deacon, 1990).

Pythium mycoparasiticum differs in colony extension rate on

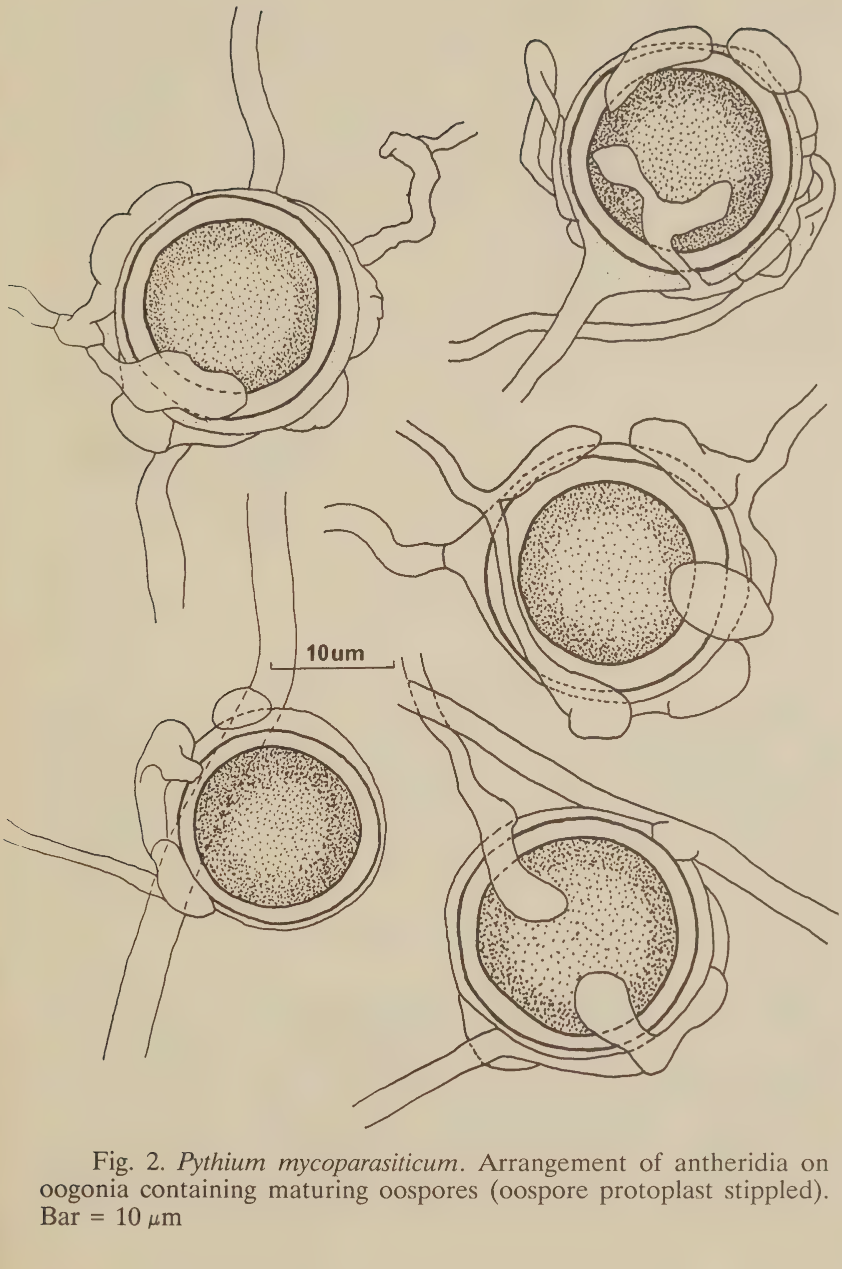


Fig. 2. *Pythium mycoparasiticum*. Arrangement of antheridia on oogonia containing maturing oospores (oospore protoplast stippled). Bar = 10 μm

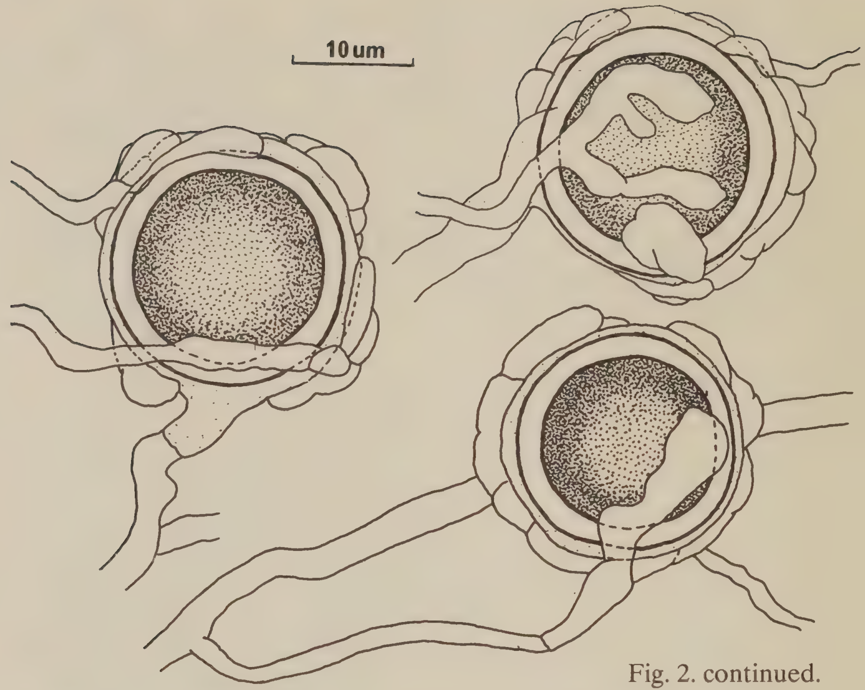


Fig. 2. continued.

different media (Table 1). Its growth was markedly stimulated on sunflower seed agar (SSA, prepared from 2 g crushed, boiled seed per litre of water agar) compared with on potato-dextrose agar (PDA), cornmeal agar, water agar or various dilutions of PDA. It also grows quite rapidly (c. 20 mm radial extension $24\ h^{-1}$) on carrot agar at $25^{o}C$. Extension growth by two other slow-growing species, *P. scleroteichum* (**CBS** 294.37) and *P. vexans* de Bary (**CBS** 270.38), was not stimulated by SSA (Table 1). The increased growth rate of *P. mycoparasiticum* on some media may be a response to sterols, as Child, Defago & Haskins (1969) reported for the mycoparasite *P. acanthicum*.

Pythium mycoparasiticum has always been isolated by placing moist or air-dried crumbs of soil on PDA plates previously colonised by other fungi, such as *Phialophora* sp. **IMI** 187786 (Deacon & Henry, 1978; Foley & Deacon, 1985). It is detected by the presence of its characteristic sexual structures across the host colony and is isolated by sub-culturing onto conventional agar media. *P. oligandrum* grows in the same conditions, but more rapidly so it sometimes precludes detection or isolation of *P. mycoparasiticum*. Nervertheless, a fungus resembling *P. mycoparasiticum* was detected in this way from 17% of 164 samples of soil, sediment and other natural substrata from Britain, from sites ranging from northern Scotland to southern England. It was found mainly in arable or other "disturbed" soils of pH 5.0-7.0 (Foley & Deacon, 1975). It did not rot cucumber fruits on wound-inoculation (Deacon & Henry, 1978) and in our work it did not reduce the emergence of wheat (*Triticum aestivum*), pea (*Pisum sativum*), Brussels sprout (*Brassica oleracea* var. *gemmifera*) or spring onion (*Allium cepa*) when seeds were sown over colonised agar disks in perlite. It thus seems to be non-pathogenic to plants.

Table 1. Colony radial extension rates (mm 24 h^{-1}, means ± S.E. of 3 replicates) of *P. mycoparasiticum* (IMI 341972), *P. scleroteichum* (CBS 294.37) and *P. vexans* (CBS 270.38) on potato-dextrose agar (PDA) and sunflower seed agar (SSA).

	PDA	SSA
P. mycoparasiticum	7.2 ± 0.4	13.5 ± 0.2
P. scleroteichum	18.9 ± 0.1	18.1 ± 0.5
P. vexans	12.0 ± 0.3	12.9 ± 0.1

We thank the Science and Engineering Research Council for a Research Studentship (to S.A.K.L.) and the Agricultural and Food Research Council for a Postdoctoral Research Assistantship (L.A.B.) during this work. We are very grateful to Dr P. M. Smith for help with the latin diagnosis and to Dr M. W. Dick for helpful discussion.

REFERENCES

CHILD, J, J., DEFAGO, G. & HASKINS, R. H. (1969). The influence of carbon and nitrogen nutrition on growth and sterol-induced sexuality of *Pythium* PRL 2142. *Mycologia* **61**, 1096-1105.

DEACON, J. W. & HENRY, C. M. (1978). Mycoparasitism by *Pythium oligandrum* and *P. acanthicum*. *Soil Biology and Biochemistry* **10**, 409-415.

DICK, M. W. (1990). Keys to *Pythium*. Reading, U.K.: published by author.

DRECHSLER, C. (1930). Some new species of *Pythium*. *Journal of the Washington Academy of Sciences* **20**, 398-418.

DRECHSLER, C. (1934). *Pythium scleroteichum* n.sp. causing mottle necrosis of sweet potatoes. *Journal of Agricultural Research* **49**, 881-890.

FOLEY, M. F. & DEACON, J. W. (1985). Isolation of *Pythium oligandrum* and other necrotrophic mycoparasites from soil. *Transactions of the British Mycological Society* **85**, 631-639.

FOLEY, M. F. & DEACON, J. W. (1986). Physiological differences between mycoparasitic and plant-pathogenic *Pythium* spp. *Transactions of the British Mycological Society* **86**, 225-231.

LAING, S. A. K. & DEACON, J. W. (1990). Aggressiveness and fungal host ranges of mycoparasitic *Pythium* species. *Soil Biology and Biochemistry* **22**, 905-911.

LAING, S. A. K. & DEACON, J. W. (1991). Video microscopical comparison of mycoparasitism by *Pythium oligandrum, P. nunn* and an unnamed *Pythium* species. *Mycological Research* (in press).

LIFSHITZ, R., STANGHELLINI, M. E. & BAKER, R. (1984a). A new species of *Pythium* isolated from soil in Colorado. *Mycotaxon* **20**, 373-379.

LIFSHITZ, R., SNEH, B. & BAKER, R. (1984b). Soil suppressiveness to *Pythium ultimum* induced by antagonistic *Pythium* species. *Phytopathology* **74**, 1054-1061.

LIFSHITZ, R., DUPLER, M., ELAD, Y. & BAKER, R. (1984c). Hyphal interactions between a mycoparasite, *Pythium nunn*, and several soil fungi. *Canadian Journal of Microbiology* **30**, 1482-1487.

MIDDLETON, J. T. (1943). The taxonomy, host range and geographical distribution of the genus *Pythium*. *Memoirs of the Torrey Botanical Club* **20**, 1-171.

PLAATS-NITERINK, A.J. VAN DER (1981). Monograph of the genus *Pythium. Studies in Mycology* **21**, 242 pp.

SHAHZAD, S., COE, R. & DICK, M. W. (1991). Biometry of oospores and oogonia of *Pythium* (Oomycetes): the independent taxonomic value of calculated ratios. *Botanical Journal of the Linnaean Society* (in press).

MYCOTAXON

Volume XLII, pp. 9-15 October-December 1991

GLOMUS MORTONII SP. NOV., A PREVIOUSLY UNDESCRIBED SPECIES IN THE GLOMACEAE ISOLATED FROM THE TALLGRASS PRAIRIE IN KANSAS[1]

STEPHEN P. BENTIVENGA and B.A.D. HETRICK[2]

Department of Plant Pathology
Throckmorton Hall
Kansas State University
Manhattan, KS 66506-5502

Introduction

A survey of the Glomales (Morton and Benny, 1990) from native tallgrass prairie soil collected from the Konza Prairie Research Natural Area (KPRNA, Manhattan, KS) revealed spores of an undescribed *Glomus* species. Soil from the site is a Chase silty clay loam, fine montmorillonitic, mesic Aquic Argiudoll with pH 6.2, 4.5% O.M., and 4.0 mg/kg available P (Bray I). Spores were extracted from soil by wet-sieving and decanting followed by sucrose density gradient centrifugation (Daniels and Skipper, 1982). Descriptions and observations reported in this study are from specimens mounted in polyvinyl alcohol-lactic acid-glycerol (PVLG, Koske and Tessier, 1983) or PVLG and Melzer's reagent (1:1 v/v). Terminology used follows that of Walker (1983) and Morton (1988). Specimens were observed with brightfield (BF) and Nomarski interference contrast (NI) microscopy using a Leitz Dialux 20 and an Olympus BH-2 photomicroscope, respectively. Spore and wall dimensions, measured with an ocular micrometer, are reported as means (size ranges in parentheses) of at least 200 spores. Sporocarp and spore dimensions are reported as [smallest diameter] x [largest diameter]. Holotypes have been deposited in the Oregon State University Herbarium, and isotypes have been deposited at the Kansas State University Herbarium.

---

[1] Contribution no. 91-486-J from the Kansas Agricultural Experiment Station, Kansas State University, Manhattan, KS.

[2] To whom all correspondence should be addressed.

Description

Glomus mortonii Bentivenga et Hetrick, *sp. nov.* (Figures 1-3)

Sporocarpia subglobosa vel irregularia, (90-)290(-450) x (140-)320(-610) μm, sporis 2-10. Sporae tunica (2-)15(-49) μm crassa, sporas adpressa sed tacile separata, hyphis hyalinis, sinuatis, (9-) 16(-21) μm in diam, parietibus (3-)5(-8) μm crassis. Sporae globosae, subglobosae, pyriformes, reniformes, vel irregulares,(37-)125(-210) x (44-)149(-275) μm, singulatim vel in sporocarpiis efformatae, parietibus tribus (1-3): (1) hyalino, mucilagino, evenescenti, (0.6-)0.8(-1.2) μm crasso, in solutione Melzeri pallide roseo; (2) hyalino, lamelloso, (0.5-)3.0(-6.3) μm crasso; (3) lamellis usque novem, luteo vel spadiceo, (1.1-)2.9(-6.3) μm crasso. Hyphae sustenantes variabiles, rectae vel interdum curvatae, cylindricae, infundibuliformes vel irregulares, (6.0-)10.8(-13.0) μm in diam.

Sporocarps formed in soil, subglobose to irregular, (90-)290(-450) x (140-) 320(-610) μm, composed of 2-10 spores. Mantle enveloping individual spores, (2-) 15(-49) μm thick, appressed to spore proper but easily detached; composed of hyaline, sinuous hyphae (9-)16(-21) μm thick, with walls (3-)5(-8) μm thick; not reacting with Melzer's solution. Spores globose to subglobose, pyriform, reniform to irregular, (37-) 125(-210) x (44-)149(-275) μm (excluding mantle) produced singly or in sporocarps; yellow to yellow-brown in reflected light. Spore wall structure (murograph, Fig. 1) of three walls (1-3) in one group (A). Outer wall (1) hyaline, mucilagenous, evanescent, often absent from mature spores, (0.6-)0.8(-1.2) μm thick; turning light pink in Melzer's reagent. Wall 2 hyaline in transmitted light, laminated, with laminae imbedded in a gelatinous matrix, (0.5-)3.0(-6.3) μm thick; continuous with hyphal attachment; generally thickest near point of hyphal attachment. Wall 3 laminated with up to 9 laminae, yellow to yellow-brown in transmitted light, (1.1-)2.9(-6.3) μm thick; initially continuous with subtending hypha but tapering to an end 25 to 90 μm from the spore proper. Neither wall 2 or 3 reacting with Melzer's solution. Hyphal attachment highly variable, straight or occasionally recurved, cylindrical to flared to irregular; (6.0-)10.8 (-13.0) μm wide. Pore at point of hyphal attachment open in immature spores, becoming occluded by innermost laminae of wall 3. Spore lumen contents globular with one to many lipid globules which may coalesce upon crushing. Subtending hyphae continuous with mantle, (9.6-)14.1(-24.8) μm wide, with hyaline, unevenly thickened walls (2.4-)4.3(-7.9) μm thick; may be absent from mature spores.

DISTRIBUTION AND HABITAT: Known only from a native tallgrass prairie site (KPRNA) near Manhattan, KS (See Introduction for soil characteristics).

MYCORRHIZAL ASSOCIATIONS: Unknown. Associated in the field with roots of *Andropogon gerardii* Vitm. and *Sorghastrum nutans* (L.) Nash, however, attempts to pot culture the fungus in the greenhouse with *A. gerardii* and *Schizachyrium scoparium* (Michx.) Nash have failed.

ETYMOLOGY: Named after Dr. Joseph B. Morton in recognition of his contributions and innovative approach to the systematics of the Glomales.

SPECIMENS EXAMINED: Kansas: Riley Co.; Konza Prairie Research Natural Area, ca. 10 km S. of Manhattan; among roots of *Andropogon gerardii* Vitm. and *Sorghastrum nutans* (L.) Nash. Holotype: s.n. OSC!, Oct. 3, 1989. Isotype: s.n. KSC!, Oct. 3, 1989. Paratypes: Bentivenga #1-5, Oct. 3-15, 1989.

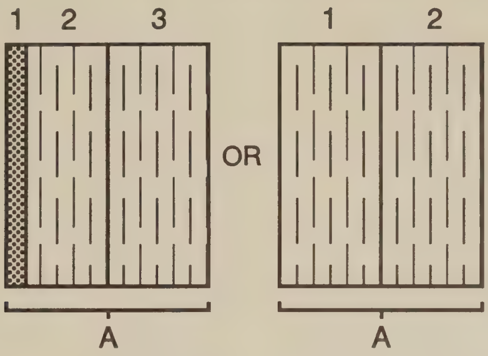


Figure 1. Murograph of *Glomus mortonii* Bentivenga & Hetrick. Walls 1-3 occur in one group (A). Dotted fill = evanescent wall, dashed fill = laminated wall (after Walker, 1983). Note that the evanescent wall may be absent.

Discussion

Spores of *G. mortonii* form singly or in sporocarps in soil. Spores in sporocarps frequently mature asynchronously with one spore approaching maturity before new spores are initiated. Developmentally, walls 1 and 2 form first, with wall 3 forming after wall 2 has reached its maximum thickness. Wall 2 is generally thicker in small immature spores than in larger mature spores suggesting that the wall may stretch and become thinner as the spore grows and matures. The ontogeny of the mantle is not known, but it seems to arise from the hyaline laminated wall of the subtending hypha (Fig 3C).

The hyaline laminated wall (wall 2) of *G. mortonii* can easily be mistaken for a unit wall. The laminae are indistinct and difficult to observe without the aid of Nomarski interference contrast. They are most easily seen in immature spores (Fig. 3A) and the thick-walled hyphae (Fig. 3B). The laminae seem to be imbedded in a gelatinous matrix similar to the laminated hyaline wall of *G. clarum* Nicolson and Schenck (see Morton, 1989). Because of similarities in wall structure, size, and color, single spores of *G. mortonii* which have had their mantle detached may easily be mistaken for *G. clarum.* However, the two species are readily distinguished since most spores of *G. mortonii* retain their distinct mantle even after sucrose gradient centrifugation and by the sporocarpic nature of *G. mortonii.*

The mantle of *G. mortonii* closely resembles the peridium of *G. sinuosa* (Gerdemann & Bakshi) Almeida & Schenck (= *Sclerosystis sinuosa*). Both are composed of thick-walled, sinuous hyphae. The two species are readily distinguished using a dissecting microscope since spores of *G. sinuosa* are generally obovate to clavate and are produced radially from a central plexus of hyphae. *G. mortonii* sporocarps do not display this type of organization.

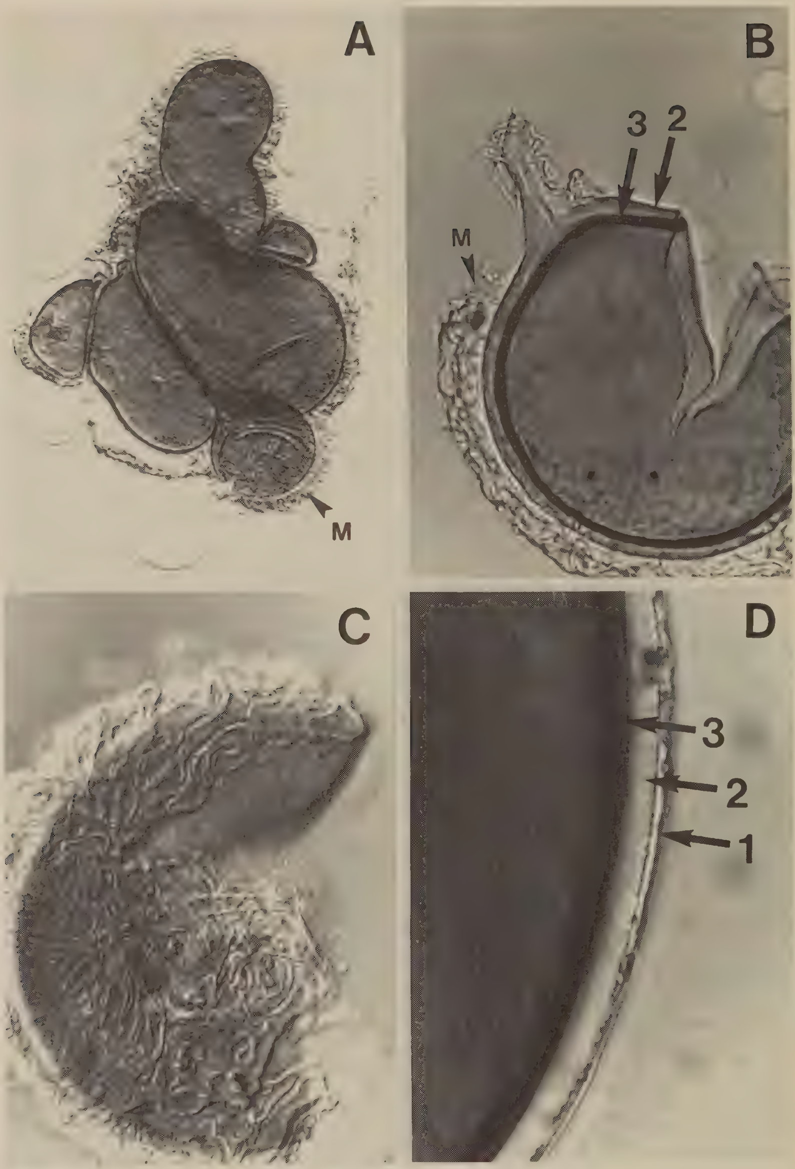


Figure 2. Spores of *Glomus mortonii*. **A.)** Sporocarp with mantle (M). Nomarski interference (NI) microscopy, x 870. **B.)** Spore displaying mantle (M), walls 2 and 3, and subtending hypha. Bright field (BF) microscopy, x 3,440. **C.)** Surface view of mantle. Note thick-walled, sinuous hyphae. NI, x 3,350. **D.)** Spore wall structure (walls 1-3). NI, x 8,730.

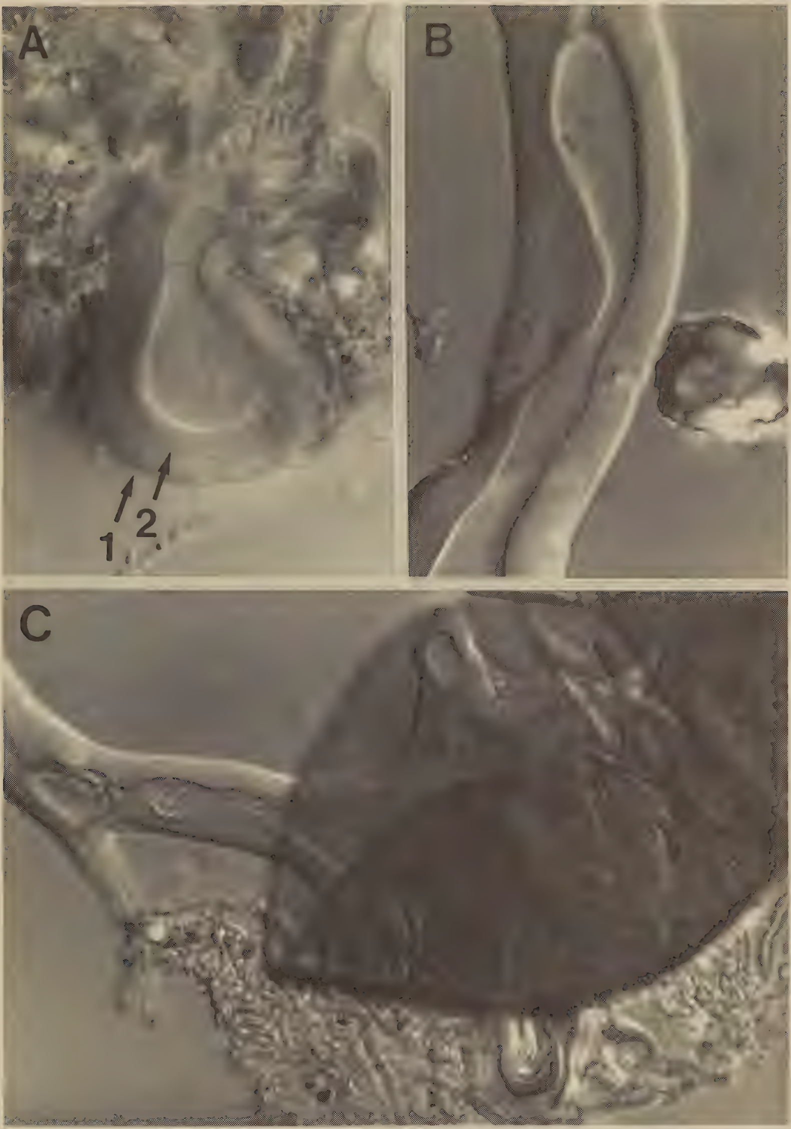


Figure 3. *Glomus mortonii*. A.) Wall structure (walls 1-2) of immature spore. Note laminae in wall 2. Wall 3 has not yet formed. NI, x 8,600. B.) Subtending hypha with laminated hyaline wall. This wall is contiguous with wall 2 of the spore. Note the unevenly thickened walls. NI, x 6,950. C.) Subtending hypha proliferating to form the spore mantle. NI, x 4,340.

Spores of *G. mortonii* superficially resemble those of *G. mosseae* (Nicol. & Gerd.) Gerdemann & Trappe in having a mantle and in having spores of different sizes occurring in the same sporocarp (Morton, 1989). However, *G. mortonii* differs from *G. mosseae* in several ways. *G. mosseae* possesses a thin (0.5 µm) hyaline outer unit wall, while the hyaline laminated wall (wall 2) of *G. mortonii* is relatively thick (3.0 µm). Also, the peridial hyphae of *G. mosseae* are narrow (2-12 µm) and not sinuous in contrast to the thicker (9-21 µm) and distinctly sinuous mantle hyphae of *G. mortonii*.

Glomus tortuosum Schenck and Smith resembles *G. mortonii* in possessing a sinuate hyphal mantle. However, the mantle hyphae of *G. tortuosum* are thin-walled and become pigmented whereas those of *G. mortonii* are thick-walled (5 µm) and remain hyaline. Furthermore, *G. tortuosum* does not produce a hyaline laminated wall or an outer evanescent wall as does *G. mortonii*. *G. mortonii* produces the hyaline laminated wall (wall 2) prior to the formation of the colored laminated wall (wall 3). Since the development of the spore proper is quite different in these two species, we speculate that there is not a strong ancestral relationship between these species and that the possession of a sinuate mantle may instead represent the convergent evolution of these two fungi.

Glomus globiferum Koske and Walker also produces a hyphal mantle (called a peridium by Koske and Walker, 1986). The vesiculate swellings of *G. globiferum* could be confused with immature spores in a sporocarp of *G. mortonii*. However, the mantle hyphae of *G. globiferum* are not sinuous and mature spores of *G. globiferum* possess one or two inner membranous walls, which are lacking in *Glomus mortonii*. The vesiculate swellings of *G. globiferum* (which may be secondary spores) have a wall structure similar to immature spores of *G. mortonii*. Koske and Walker (1986) report that the outer hyaline unit wall of the swellings is generally thinner than the inner pigmented laminated wall. The opposite trend is true (wall 2 thicker than wall 3) for immature spores of *G. mortonii*. Furthermore, *G. mortonii* possesses an evanescent mucilagenous layer and its hyaline wall is laminated. Spores of *G. globiferum* are also darker in color than those of *G. mortonii*, the former being orange-brown to red-brown or occasionally black.

Acknowledgments

We would like to express our thanks to Dr. R.E. Koske for observing specimens and contributing valuable comments. We also thank Dr. James Trappe for providing the Latin diagnosis and Dr. Steve Upton for assistance in preparing micrographs.

Literature Cited

Daniels, B.A. and Skipper, H.D. 1982. Methods for the recovery and quantitative estimation of propagules from soil. In: Methods and Principles of Mycorrhizal Research, (N.C. Schenck, ed.). Am. Phytopathol. Soc., St. Paul, Minnesota. pp. 29-35.

Koske, R.E. and Tessier, B. 1983. A convenient, permanent slide mounting medium. Newsl. Mycol. Soc. Am. **34**: 59.

Koske, R.E. and Walker, C. 1986. *Glomus globiferum*: a new species of Endogonaceae with a hyphal peridium. Mycotaxon **26**: 133-142.

Morton, J.B. 1988. Taxonomy of VA mycorrhizal fungi: classification, nomenclature, and identification. Mycotaxon **32**: 267-324.

Morton, J.B. 1989. Mycorrhizal Fungi Slide Set: Morphological Characters Important in Identifying Endomycorrhizal Fungi in the Zygomycetes. Audio-Visual-Electronic Publication 2. Agric. For. Expt. Stn., West Virginia University, Morgantown, West Virginia.

Morton, J.B. and Benny, G.E. 1990. Revised classification of arbuscular mycorrhizal fungi (Zygomycetes): A new order, Glomales, two new suborders, Glomineae and Gigasporineae, and two new families, Acaulosporaceae and Gigasporaceae, with an emendation of Glomaceae. Mycotaxon **37**: 471-491.

Walker, C. 1983. Taxonomic concepts in the Endogonaceae: Spore wall characteristics in species descriptions. Mycotaxon **18**: 443-455.

MYCOTAXON

Volume XLII, pp. 17-27 October-December 1991

NEW RECORDS OF MYXOMYCETES FROM MEXICO

L. HERNANDEZ-CUEVAS, M. RODRIGUEZ-PALMA,
G. GALINDO-FLORES and A. ESTRADA-TORRES.

Centro de Investigación en Ciencias Biológicas,
Universidad Autónoma de Tlaxcala
and
Escuela Nacional de Ciencias Biológicas,
Instituto Politécnico Nacional
(Postal Address: Apartado Postal 26-393,
México 02860, D.F., México).

Abstract

Seven species of Myxomycetes are recorded for the first time from Mexico: ***Enteridium olivaceum*** Ehremb., ***Dictydium mirabile*** (Rost.) Meylan, ***Prototrichia metallica*** (Berk.) Massee, ***Trichia floriformis*** (Schw.) Lister, ***Craterium paraguayense*** (Speg.) G. Lister, ***Physarum rubiginosum*** Fr. and ***Diderma radiatum*** (L.) Morgan. Some data about ***Physarum tropicale*** Macbr. also are discussed.

Resumen

Siete especies de mixomicetos son registrados por primera vez para la República Mexicana: ***Enteridium olivaceum*** Ehremb., ***Dictydium mirabile*** (Rost.) Meylan, ***Prototrichia metallica*** (Berk.) Massee, ***Trichia floriformis*** (Schw.) Lister, ***Craterium paraguayense*** (Speg.) G. Lister, ***Physarum rubiginosum*** Fr. y ***Diderma radiatum*** (L.) Morgan. Se discuten también algunos datos sobre ***Physarum tropicale*** Macbr.

Introduction

Myxomycetes from Mexico were first published by Macbride & Smith (1896). Since that date, these organisms have been studied by several workers (Braun & Keller, 1976; Gómez-Sánchez & Castillo, 1981; Keller & Braun, 1977; López et al., 1979; 1981; Trujillo et al., 1986; Villarreal, 1983; 1990) and Braun & Keller (1986) listed all Myxomycetes (164 species) known from Mexico up to that year.

While working on the taxonomy and ecology of Myxomycetes from the *Abies* forest of Malintzin Volcano, in the State of Tlaxcala, we found seven myxomycete species unknown for Mexico. In this paper, we describe these species and discuss their phenology and ecology. We also include notes on *Physarum tropicale*.

All specimens were deposited in the ENCB Herbarium and in the Mycological Collection of the "Centro de Investigación en Ciencias Biológicas, Universidad Autónoma de Tlaxcala". Fifty spores of each specimen examined were measured. Color descriptions were made using Munsell (U.S. Department of Agriculture, 1975), Methuen (Kornerup & Wanscher, 1978) and Kuppers (1979) color charts.

Description of species

LICEALES

Enteridiaceae

Enteridium olivaceum Ehremb.

Aethalia 13 - 21 mm X 3 - 7 mm, up to 1 mm in height, flattened, crust-like appearance, with dark green tones; peridium cartilaginous, frail, rigid, dark brown (Methuen: 7F5), cracked on the border; hypothallus membranous, brownish orange (Methuen: 7C8), translucent; pseudocapillitium formed by perforated plates with the same color and consistence of the peridium; plates erect, with intricate net-like appearance, pale yellow (Munsell: 5Y8/4 by transmitted light; spores olive (Methuen: 3F4) in mass, grayish yellow (Methuen: 3B5) by transmitted light, ovate, (10) 11 - 12 (13) µm X 13 - 15 µm, in clusters of 10 - 24 spores, spinose only in the exposed surface; spines 2 - 3 µm long.

Habitat: On standing dead tree of *Abies religiosa* Schl.

Specimens examined: TLAXCALA STATE: Ixtenco Municipality, East Slope of the Malintzin Volcano, March 10, 1989, 3250 m, legit Rodríguez-Palma # 978.

Discussion: Martin & Alexopoulos (1969) stated that this species is variable in the aethalia and spore sizes. In our collection, unlike Pando & Lado's (1987) description, the spores are rarely free and the fructification size is larger. *Enteridium olivaceum* is usually reported on coniferous wood. Mitchell et al. (1980) reported it as a summer species in Colorado, but in Mexico it seems to be a rare spring species based on one collection from the Malintzin Volcano.

Geographical distribution: This species has been reported from Western United States, Europe (Martin & Alexopoulos, 1969), Chile, Argentina, Tierra de Fuego (Farr, 1976) and the Soviet Union (Novogilov, 1985).

Cribrariaceae

Dictydium mirabile (Rost.) Meylan

Sporangia gregarious, globose, stalked, reddish brown (Methuen: 9E8), 1/5 - 1/4 of total height, 0.8 - 1.3 mm in diameter: calyculus persistent, up to 1/4 - 1/3 of spore case, membranous, silvery, sometimes iridescent; upper portion of the sporangium forming a cribrarioid net, with open to closed meshes bearing small nodes at junctions, violet brown (Methuen: 10F8) by transmitted light, sometimes with the cribrarioid net united with the calyculus by parallel ribs interconnected by very thin transverse bands; peridium sometimes persisting as a delicate membrane; stalk tapering at apex, twisted at top, 1.8 - 3.5 mm height, filled with amorphous material, plicate, violet brown (Methuen: 10F7); hypothallus membranous, dark brown to reddish brown, continuous to many sporangia; spores reddish brown (Methuen 9E7-8) in mass, pale red (Methuen: 12A4) by transmitted light, globose, nearly smooth to slightly warted, 6 - 8 μm in diameter; dictydine granules violet brown, 1 - 2 μm.

Habitat: On decaying coniferous wood and moss-covered bark of dead logs, in *Abies religiosa* forests.

Specimens examined: MEXICO STATE: Ocuilan Municipality, Zempoala Lagoon National Park, Quila Lagoon, June 27, 1987, legit Hernández-Cuevas # 20; TLAXCALA STATE: Ixtenco Municipality, East Slope of the Malintzin Volcano, May 27, 1988, legit Galindo-Flores # 44; June 27, 1988, 3300 m, legit Rodríguez-Palma # 60; July 8, 1988, 3470 m, legit Rodríguez-Palma # 91; July 14, 1988, 3150 m, legit Hernández-Cuevas # 110; March 10, 1989, 3400 m, Rodríguez-Palma # 972; Terrenate Municipality, Villarreal, El Motor, Feb. 23, 1990, legit Estrada-Torres # 2918.

Discussion: Martin & Alexopoulos (1969) suggest that this species may be a form of *D. cancellatum* (Batsch) Macbr. adapted to cold climates, but according to their description and that of Farr (1976), *Dictydium mirabile* is different in its cribrarioid net and its well developed calyculus, both of which are very conspicuous in our specimens. However, the Mexican material, like that described by Mitchell et al. (1980), is different in the presence of transverse bands connecting parallel ribs. *Dictydium mirabile* was considered a summer species by Mitchell et al. (1980), but in Mexico it grows from March to July. *Dictydium cancellatum* is abundant in the three zones where *D. mirabile* has been found.

Geographical distribution: *Dictydium mirabile* has been cited from Central Europe, Switzerland and the United States by Martin & Alexopoulos (1969), from Chile by Farr (1976), from Spain (as *Cribraria mirabilis*) by Ladó (1985) and from the Soviet Union by Novogilov (1985).

TRICHIALES
Trichiaceae
Prototrichia metallica (Berk.) Massee

Sporangia sessile to stalked, gregarious, 0.4 - 1.2 in total height, globose, reddish gold (Methuen: 6C7), brownish red (Methuen: 8C6) to red (Munsell: 10R5/6), 0.4 - 1.9 mm in diameter; peridium reddish orange (Methuen: 7B7), orange (Methuen: 5A6) to reddish yellow (Munsell: 5YR6.5/6), membranous, translucent, rugulose, bright, iridescent, with purple tints when open and bluish green tints when closed; stalk when present around 1/3 of total height, erect, black; hypothallus membranous, light yellow (Methuen: 4A4) to pale yellow (Methuen: 2A3), translucent, single or continuous to many stalks; capillitium brownish yellow (Munsell: 10YR6/6) to reddish yellow (Munsell: 5YR5/6) in mass, darkening to reddish brown with time, formed by rigid threads radiating from center of sporangium; threads pale yellow by transmitted light, branching, interweaving and tapering to pale ends; spores reddish brown (Munsell: 7.5YR5/8) to pale brown (Munsell: 10YR8/5) in mass, pale yellow (Methuen: 4A4) in transmitted light, globose, 12 - 13 µm in diameter, with long and thin spines.

Habitat: On decaying or burned coniferous wood, in an *Abies* forest. The Galindo-Flores # 832 specimen was found on trunk of a living *Abies religiosa* tree, near ground level.

Specimens examined: TLAXCALA STATE: Ixtenco Municipality, East Slope of the Malintzin Volcano, May 27, 1988, legit Hernández-Cuevas # 45; July 8, 1988, 3400 m, legit Galindo Flores # 84; July 14, 1988, 3400 m, legit Hernández-Cuevas 177; Sep. 16, 1988, legit Hernández-Cuevas # 676; Sep. 27, 1988, 3450 m, legit Galindo-Flores 684, 687; 3350 m, legit Hernández-Cuevas # 715; Nov. 4, 1988, 3250 m, legit Galindo-Flores 895; 3300m, legit Rodríguez-Palma # 697; 3400 m, legit Hernández-Cuevas # 816; 3450 m, legit Galindo Flores # 758; Nov. 26, 1988, 3250 m, legit Galindo Flores # 846, 926; Dec. 19, 1988, 3450 m, legit Galindo-Flores # 883; Jan. 20, 1989, 3250 m, legit Hernández-Cuevas 1641.

Discussion: The genus *Prototrichia* is monospecific and Kowalski (1967) reported it like very common in cold mountain areas of the United States. Mitchel et al. (1980) reported this species growing during spring and summer in Colorado. In the Malintzin Volcano it is more abundant during the cooler months of November to January. Our specimens agree with Kowalski (1967) and Martin & Alexopoulos (1969), but Mitchell et al. (1980) described three forms of this species and the Mexican material seems to belong to the small form with gold, rose and blue iridescence although the color of our specimens is more brownish.

Geographical distribution: According to Martin & Alexopoulos (1969), *P. metallica* is known from Tasmania, Europe and the United States. Novogilov (1985) cited it from the Soviet Union. As far as we know, the Mexican specimens are the first record of this genus from the Neotropics.

Trichia floriformis (Schw.) Lister
Sporangia stalked, up to 4 mm in total height, gregarious, pyriform, up to 1 mm of diameter, with double peridium; inner layer of the peridium membranous, reddish yellow by transmitted light, firmly adhering to the outer layer which is granular, dark red (Munsell: 2.5YR3/6) to blackish (Munsell: 2.5YR2.5/0), shining, with apical petaloid dehiscence; stalk thin, up to 3 mm in height, red (Munsell: 2.5YR5/6), dark red (Munsell: 2.5YR3/6) to reddish brown (Methuen: 9F7), furrowed; hypothallus membranous, small, brownish red (Methuen: 8C7) to reddish brown (Methuen: 9E8), with radial folds arising from the stalk; capillitium dense, reddish yellow (Munsell: 7.5YR6/8 - 8.5YR4/8) in mass, reddish orange, yellowish orange, reddish yellow or yellow by transmitted light, forming elaters with close spiral bands and many free sharp ends, 5 - 6 μm in diameter; spores red (Methuen: 7D-E8; Munsell: 2.5YR4/8) in mass, pale red by transmitted light, globose, nearly smooth to slightly spinulose, 12-13 μm in diameter.

Habitat: On decaying coniferous wood and moss-covered bark of dead logs, in *Abies religiosa* forest.

Specimens examined: TLAXCALA STATE: Ixtenco Municipality, East Slope of the Malintzin Volcano, July 14, 1988, 3350 m, legit Rodríguez-Palma # 158; Sep. 27, 1988, 3450 m, legit Galindo-Flores # 680; Nov. 4, 1988, 3450 m, legit Galindo-Flores # 760, 763; Nov. 26, 1988, 3150 m, legit Galindo-Flores # 788; Oct. 20, 1989, 3400 m, legit Galindo-Flores # 1185; Jan. 11, 1990, 3400 m, legit Galindo Flores # 1282; 3450 m, legit Galindo Flores # 1294, 1296; Feb. 9, 1990, 3450 m, legit Galindo-Flores # 1391; March 9, 1990, legit Hernández-Cuevas # 1819; March 10, 1990, 3450 m, legit Galindo-Flores # 1009; March 23, 1990, 3450 m, legit Galindo-Flores # 1472; April 19, 1990, 3450 m, legit Galindo-Flores # 1511, 1512.

Discussion: The spore size and total height of the sporophores of the Mexican material are slightly larger than the sizes reported by Martin & Alexopoulos (1969), but Mitchell et al. (1980) found that this occurs in montane collections of many species. *Trichia floriformis* was reported as a summer species by Mitchell et al. (1980). In our study area it fruits from July to November.

Geographical distribution: *Trichia floriformis* is a cosmopolitan species. It has been cited from Canada, the United States, Puerto Rico, Jamaica, Chile, Europe, Southern and Eastern Asia, Australia and New Zealand by Martin & Alexopoulos (1969). Farr (1976) also reported it from Costa Rica, Venezuela and Argentina. Stojanowska (1977) cited it from Poland, Beltrán-Tejera (1980) from the Canary Islands, Novogilov (1985) from the Soviet Union, and Yu & Hui Zhong (1989) from China.

PHYSARALES

Physaraceae

Craterium paraguayense (Speg.) G. Lister

Sporangia sessile, subsessile to shortly stalked, scattered, globose, pyriform, turbinate, cup-shaped to slightly terete, sometimes two or three sporangia united, 0.7 - 1.3 mm in total height, 0.2 - 1.0 mm in diameter; peridium of the lower portion of the sporangia deep magenta (Methuen: 14E8), cartilaginous, persisting like an irregular calyculus; peridium of the upper portion pale violet (Methuen: 15A3) to violet white (Methuen: 15A2) to whitish, membranous, frail, covered with calcareous granules, opening by irregularly circumscissile dehiscence; stalk when present cylindrical, stout, slightly furrowed, concolorous with the calyculus or sometimes violet brown (Methuen: 10E8), 0.2 - 0.6 mm in height; hypothallus individualized, membranous, brownish to high red (Methuen: 10E8), grayish red (Methuen: 11C6) by transmitted light; capillitium of fine hyaline threads interconnected by small calcareous, grayish magenta (Methuen: 13C5) to violet white (Methuen: 15A2), and nearly regular nodes; spores very dark violet (Methuen: 15F8) to grayish violet (Methuen: 15E6) in mass, purplish gray (Methuen: 13F2) by transmitted light, globose, densely warted, 10 - 11 µm in diameter.

Habitat: On decaying coniferous wood, dead leaves of *Quercus* and other plants and mosses growing on the ground, in *Abies-Pinus*, *Pinus-Quercus* or *Pseudotsuga-Quercus-Pinus* forests.

Specimens examined: TLAXCALA STATE: Ixtenco Municipality, East Slope of the Malintzin Volcano, Nov. 26, 1988, 3500 m, legit Hernández-Cuevas # 915; Dec. 19, 1988, 3500 m, legit Hernández-Cuevas # 996; Jan. 20, 1989, 3300 m, legit Hernández-Cuevas # 1040; Terrenate Municipality, Villarreal, El Motor, Feb. 23, 1990, legit Galindo-Flores # 966, Hernández-Cuevas # 1145; Totolac Municipality, Tepeticpac Hill, Oct. 10, 1990, 2500 m, legit Estrada-Torres # 3149.

Discussion: This species is easily distinguished by its color. Nevertheless, the Mexican material differs from the description by Martin & Alexopoulos (1969) and Farr (1976), in the absence of a pseudocolumella, the bright orange red color and venations of the hypothallus, the spore size which is larger (9 -11 µm in our specimens versus the 8 - 9 µm in the Martin & Alexopoulos description), and the more evident ornamentation of the spores. Also, the habitat of the Mexican specimens is different since it grows above 3300 m in coniferous forests. the differences exhibited here are probably due to climatic conditions at high elevation sites (Mitchell et al., 1980) and they should not be considered significant to separate the Mexican specimens in a new taxon.

Geographical distribution: This species has been recorded from southeastern United States by Martin & Alexopoulos (1969) and from Central and South America, and from Panama to Argentina by Farr (1976). With this geographical distribution, the Mexican records are not surprising. In any case, *C. paraguayense* appears to be a species restricted to the North and South American Continent. Martin & Alexopoulos (1969) considered it a tropical or subtropical species, but our specimens, although were found in the Neotropics area, they were growing in a high elevation coniferous forest.

Physarum rubiginosum Fr.

Sporangia in small clusters, sessile, globose to pulvinate, up to 1.2 mm in diameter; peridium membranous, fragile, reddish orange (Methuen: 7A8) to orange red (Methuen: 8B8), covered with bright orange scales giving the appearance of an outer wrinkled peridial layer; hypothallus inconspicuous, orange (Methuen: 5A7), membranous; capillitium consisting of white, delicate threads, interconnected by yellowish orange (Methuen: 4A7) calcareous nodes; nodes orange by transmitted light, fusiforms, regular; spores black in mass, brownish orange (Methuen: 5C6) by transmitted light, globose, warted, 9-10 μm in diameter.

Habitat: On living leaves of an angiosperm, in *Abies-Pinus* forest, and dead leaves of *Quercus* in *Pinus-Quercus* forest.

Specimens examined: TLAXCALA STATE: Ixtenco Municipality, East Slope of the Malintzin Volcano, Sept. 27, 1988, 3400 m, legit Rodríguez-Palma # 604; Totolac Municipality, Tepeticpac Hill, July 4, 1990, 2500 m, legit Rodríguez-Palma # 1808.

Discussion: *Physarum rubiginosum* is a rare species in the Malintzin Volcano. The Mexican material fits the description of Martin & Alexopoulos (1969) and Farr (1976), but its habitat is different because they reported it growing on dead wood and mosses.

Geographical distribution: This species has been cited from Europe, Canada, the United States (Martin & Alexopoulos, 1969), Jamaica, Dominica (Lesser Antilles) (Farr, 1976) and the Soviet Union (Novogilov, 1985).

Physarum tropicale Macbr.

Sporangia gregarious to scattered, stalked or rarely sessile, 0.8 - 1.2 mm in total height, subglobose to subdepressed, sometimes forming short plasmodiocarps, 0.6 - 1.0 mm in diameter, with regular circumscissile dehiscence; peridium of the upper portion membranous, iridescent, blue (Methuen: 23A6), bluish violet (Methuen: 23A6), vivid yellow (Methuen: 2A8), or green (Kuppers: C99A80M30), sometimes lusterless, bluish white (Methuen: 20A2) to gray (Methuen: 22C1), covered with white lime flakes, reddish white (Methuen: 9A2), to dull red (Methuen: 10B3) when the sporangium is empty, pinkish white by transmitted light (Munsell: 5YR8/2); the lower portion is dark gray, gray (Methuen: 5D1) sometimes with yellow brown (Methuen: 5E8) iridescence and sometimes forming a calyculus like structure or leaving only a disk over the stalk; stalk short, 0.3 - 0.5 mm tall, stout, furrowed, olive (Methuen: 3E8) to olive gray (Methuen: 3D2), yellowish white (Methuen: 4A2) on furrows; hypothallus inconspicuous; capillitium of thin, hyaline threads, attached to the peridium, interconnected by pale brown (Munsell: 10YR8/3) angular or rarely rounded nodes; spores black in mass, brown (Munsell: 7.5YR5/6) by transmitted light, globose, spinose, 10 - 12 µm in diameter, spines conical, stout with a rounded apex.

Habitat: On decaying coniferous wood, dead leaves of *Abies* and moss-covered bark of dead logs, in *Abies religiosa* forest.

Specimens examined: TLAXCALA STATE: Ixtenco Municipality, East Slope of the Malintzin Volcano, Sept. 21, 1988, 3300 m, legit Galindo-Flores # 641; Nov. 4, 1988, 3500 m, legit Galindo-Flores # 767; Nov. 26, 1988, 3500 m, legit Hernández-Cuevas # 915.

Discussion: Our material agrees with Martin & Alexopoulos's (1969) and Farr's (1976) descriptions, except in the ornamentation and slightly smaller size of the spores, and the presence of the furrows on the stalk. However, other morphological characters are similar. Martin & Alexopoulos (1969) stated that this species is characterized by its turbinate sporangia with iridescent upper portion and persistent cup-like lower portion and by its dense capillitium, thick and brown stalk, and distinctly warted and purple spores, but our specimens are principally subglobose or depressed-globose and their spores are spinose.

Distribution: The type collection of this species is from Mxico, probably from Jalapa, Veracruz State, or the nearby forests, but these data is not precise. The specific name suggests a tropical habitat, which is found in that Mexican zone, but our specimens are from a typical coniferous forest, at 3300-3500 m of height, in a place where climatic conditions are cold, (C(E)W) according to

Koppen's climatic classification and modified by García (1973). For this reason, we think that the type locality could be the coniferous forest near Jalapa City, maybe in the "Cofre de Perote" Volcano, which is in the same Cordillera of the Malintzin Volcano. Farr (1976) cited this species from Venezuela but she does not give precise data concerning the habitat where the Venezuelan specimens were collected. Also, she stated "the Venezuela listing is based on Oberwinkler 15025b (BPI) which seems to fit *Ph. tropicale* fairly well, or at least better than any other species", suggesting that the Venezuelan material could not belong to this species. If this is correct, *Ph. tropicale* may be an endemic species of Mexico. Nevertheless, this species is known only from Neotropics.

Didymiaceae

Diderma radiatum (L.) Morgan

Sporangia gregarious to crowded, sessile to shortly stalked, 0.7 - 0.8 mm in total height, globose to pulvinate, 0.6 - 1.3 mm in diameter, with stellate dehiscence; peridium persistent, double, with the outer layer cartilaginous, brownish orange (Methuen: 6C6), dark brown (Methuen: 8F7) to blackish, firmly adherent to the fragile, yellowish white (Methuen: 1A2) to white (Munsell: 5YR8/1) inner layer;stalk when present olivaceous brown, short, rugous, translucent, calcareous; columella ellipsoid, hemispheric or campanulate, solid, prominent, calcareous, yellowish white (Methuen: 4A2), pinkish white (Munsell: 5YR8/3), to reddish yellow (Munsell: 7.5YR7/6), enveloped in a membranous extension of the stalk, in some specimens forming a crown-like apex, striate and gray (Munsell: 5YR6/1) at the junction with the peridium; capillitium dense, consisting of delicate threads, hyaline or sometimes dark yellowish brown (Munsell: 10YR4/6), with sharp to obtuse free tips; spores black in mass, dark yellowish brown (Munsell 10YR4/4) by transmitted light, globose, closely warted, (9) 11 - 12 (16) µm in diameter.

Habitat: On decaying coniferous wood, in an *Abies religiosa* forest.

Specimens examined: TLAXCALA STATE: Ixtenco Municipality, East Slope of the Malintzin Volcano, May 27, 1988, legit Galindo-Flores # 25; Hernández-Cuevas # 47; July 8, 1988, 3100 m, legit Galindo-Flores # 85; 3400 m, legit Hernández-Cuevas # 96; 3470 m, legit Rodríguez-Palma # 88; July 14, 1988, 3350 m, legit Hernández-Cuevas # 198; 3470 m, legit Galindo-Flores # 172; Hernández-Cuevas # 166; 3500 m, legit Rodríguez-Palma # 159; July 30, 1988, 3200 m, legit Rodríguez-Palma # 198.

Discussion: Martin & Alexopoulos (1969) stated that this species is variable and difficult to delimit. Our specimens agree with Farr's description, but the inside of the sporophore is always covered with a calcareous layer.

Mitchell et al. (1980) found this species throughout most of the year. At the Malintzin Volcano it is especially abundant in July.

Geographical distribution: This species is cosmopolitan (Martin & Alexopoulos, 1969).

Acknowledgement

The authors acknowledge to Dr. H. W. Keller, Dr. Miguel Ulloa and Sc. M. Lucía Varela for the revision of the manuscript of this paper.

Literature cited

Beltrán-Tejera, E., 1980. Catálogo de los hongos saprófitos presentes en el Archipielago Canario. Instituto de Estudios Canarios, La Laguna de Tenerife.

Braun, K.L. and H.W. Keller, 1976. Myxomycetes of Mexico I. Mycotaxon 3 (2): 247 - 317.

Braun, K.L. and H.W. Keller, 1986. Myxomycetes of Mexico III. Rev. Mex. Mic. 2: 25 - 39.

Farr, M.L., 1976. Myxomycetes. Flora Neotropica 16, New York Botanical Garden, New York.

García, E., 1973. Modificaciones al sistema de clasificación climática de Koppen. UNAM, Mexico, D.F.

Gómez-Sánchez, A. and J. Castillo, 1981. Estudio sobre los mixomicetos del estado de Nuevo León. Bol. Soc. Mex. Mic. 15: 199 - 223.

Keller, H.W. and K. L. Braun, 1977. Myxomycetes of Mexico II. Bol. Soc. Mex. Mic. 11: 163 - 180.

Kornerup, A. and J.H. Wanscher, 1978. Methuen handbook of colour. Methuen, London.

Kowalski, D.T., 1967. Observations on the Dianemaceae. Mycologia 59 (6): 1075 - 1084.

Kuppers, H., 1979. Atlas de los colores. Blume, Barcelona.

Ladó, C., 1985. Estudios sobre Myxomycetes VII. Bol. Soc. Micol. Castellana 10: 19 - 26.

López, A., A. Sosa and L. Villarreal, 1979. Estudio sobre los mixomicetos del estado de Veracruz I. Bol. Soc. Mex. Mic. 13: 127-144.

López, A., L. Villarreal and A. Sosa, 1981. Estudio sobre los mixomicetos del estado de Veracruz V. Bol. Soc. Mex. Mic. 16: 95 - 104.

Martin, G.W. and C.J. Alexopoulos, 1969. The Myxomycetes. University of Iowa Press, Iowa.

Macbride, C.H. and C.L. Smith, 1896. The Nicaraguan Myxomycetes. With notes on certain Mexican species. Bull. Lab. Nat. Hist. State Univ. Iowa 4 (1): 73 - 75.

Mitchell, D.H., S.W. Chapman and M.L. Farr, 1980. Notes on Colorado fungi IV: Myxomycetes. Mycotaxon 10 (2): 299 - 349.

Pando, F. and C. Ladó, 1987. Myxomycetes cortícolas ibéricos I: Especies sobre *Juniperus thurifera*. Bol. Soc. Micol. Madrid 11 (2): 203 - 212.

Stojanowska, W., 1977. Zmiany we florze sluzowców rezerwatu Puczczy

Snieznej Bialki. Acta Mycol. 13 (1): 99 - 107.

Trujillo, F., M.M. Castañeda and L. Guzmán-Dávalos, 1986. Hongos del estado de Jalisco VI. Los mixomicetos conocidos. Tiempos de Ciencia 5: 42 - 54.

U.S. Department of Agriculture, 1975. Munsell soil color chart. Kollmorgen Corporation, Baltimore.

Villarreal, L., 1983. Algunas especies de Myxomycetes no registradas del estado de Veracruz. Bol. Soc. Mex. Mic. 18: 153 - 164.

Villarreal, L., 1990. Estudios sobre los Myxomycetes de México I. Nuevos registros. Micol. Neotrop. Aplic. 3: 67 - 79.

Yu, L. and L. Hui-Zhong, 1989. Myxomycetes from China I. A checklist of Myxomycetes from China. Mycotaxon 35 (2): 429 - 436.

MYCOTAXON

Volume XLII, pp. 29-34 October-December 1991

A NEW SPECIES OF PHANEROCHAETE (APHYLLOPHORALES,CORTICIACEAE) FROM INDIA

A.B.DE

Department of Botany,Burdwan Raj College,Burdwan 713 104,W.B.,India

SUMMARY

A new species of Phanerochaete (Phanerochaete citri De,sp.nov.) has been described and illustrated.The species was found growing on a dead branch of Citrus medica var.acida Brandis at Burdwan, West Bengal, India.

During a routine mycological excursion a non-poroid fungus of Aphyllophorales (Corticiaceae) was collected by the author from a dead branch of Citrus medica var.acida Brandis at Burdwan,West Bengal,India on October21,1988.After investigations it was found to be a new species of the genus Phanerochaete Karst. Complete descriptions of basidiocarp and culture of this species have been presented herein and the name coined for this fungus is :

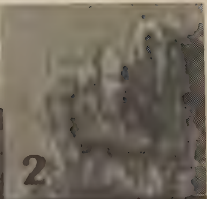
Phanerochaete citri De,sp.nov.

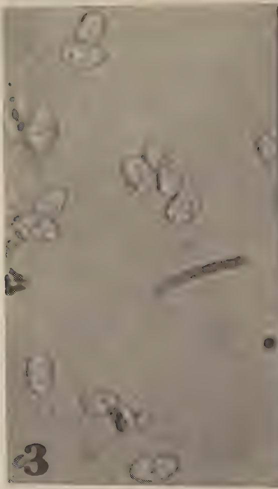
Fructificatio resupinata,effusa,adnata,tenuis,membranacea;hymenio albido vel ochraceo,levi;margo indeterminato. Systema hyphale monomiticum. Hyphae generativae hyalinae, non-fibulatae,tenuitunicatae;basidia hyalina,clavata, 4-sterigmatibus, 28.4-33.6x4.2-5.6 µm; basidiosporae 5.6-7.0x 3.5-4.2 µm, ellipsoideae,levis,hyalinae,tenuitunicatae,non-amyloideae;cystidiis nullis.

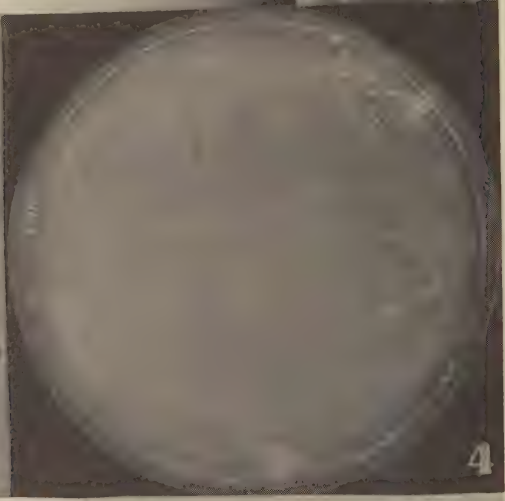
HOLOTYPUS lectus ad locum Burdwan, West Bengal, India, die 21 Octobri, 1988 et positus in herbario fungorum in sectio Botanicae, Burdwan Raj College, Burdwan, West Bengal, India (sub numero BRCMH C-881); in herb. Kew conservatus.

Basidiocarp (Fig.1) resupinate, broadly effused, adnate, thin, up to 480 µm thick, membranaceous, beginning as small patches, elongating and coalescing into elongate patches, up to 12.0x2.0 cm; context homogeneous, yellowish-white; hymenial surface white to cream, becoming black in 2% KOH, smooth; margin indeterminately thinning out, concolourous with hymenial surface.

1


2


3


4

5

6

Hyphal system monomitic. Generative hyphae (Fig.7) hyaline, much branched, often showing H-connection, simple septate, thin -walled, smooth, 2.8-4.2 um in diam.; basidia (Figs. 2 & 8) hyaline, thin-walled, clavate 28.4-33.6x4.2-5.6um, tetrasterigmatic, sterigmata 3.5-4.2um long; basidiospores (Figs.3 & 9) hyaline, thin-walled,smooth,ellipsoid,5.6-7.0x3.5-4.2um, apiculate, non-amyloid; cystidia absent.

HOLOTYPE: BRCMH C-881, October 21, 1988. Kept in the Mycological Herbarium, Department of Botany, Burdwan Raj College, Burdwan, West Bengal, India. A portion of the specimen has been deposited in the Kew Herbarium, Richmond , Surrey, England [K(M) 17171].

TYPE LOCALITY: Burdwan, West Bengal, India.

ETYMOLOGY: The specific epithet after the generic name (*Citrus*) of its host (*Citrus medica* var. *acida* Brandis).

DESCRIPTION OF CULTURE

Growth characteristics: Growth on 1.5% malt extract agar at 28°C rapid, covering the plate in 4 weeks. Advancing zone even, hyaline, thin, appressed in a very narrow zone. Mat white, short cottony to start with, soon becoming somewhat sodden and appressed showing pin-like dotted areas scattered irregularly particularly towards the margin (Fig. 4). Reverse bleached. Odour mild, not fruiting in 6 weeks.

Oxidase reactions negative.On gallic acid medium (Fig. 5) no reaction, with good mycelial growth, up to 5.5 cm in radius in 2 weeks. On tannic acid medium (Fig. 6) no reaction, with a trace of growth around the inoculum in 2 weeks.

Microscopic characteristics: Advancing mycelium- hyphae hyaline, thin-walled; smooth, simple-septate, infrequently branched, 2.8-3.5um in diam. (Fig. 10).

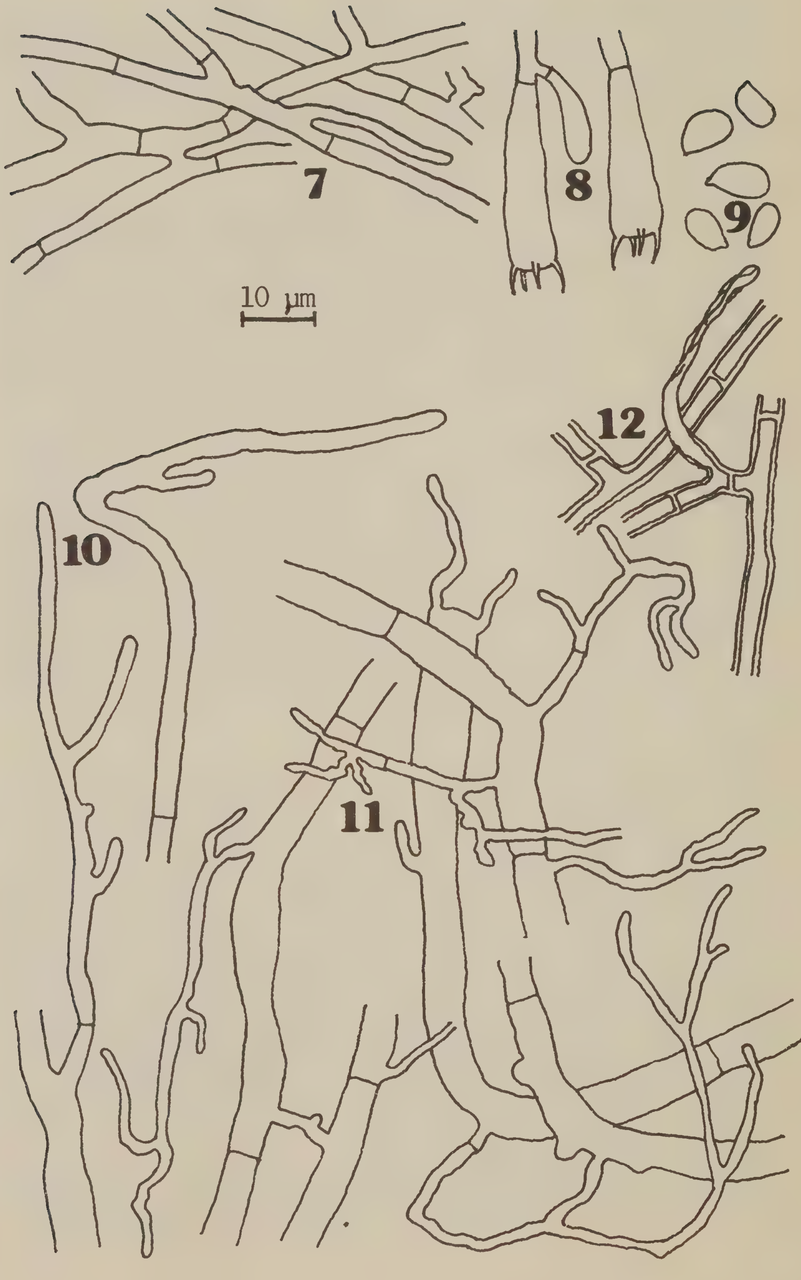
Aerial mycelium- hyphae hyaline, thin-walled, smooth, septate, lacking clamps, irregularly wide, 4.5-7.0um in diam. bearing narrower branches of 1.4-2.8um diam. (Fig. 11).

Submerged mycelium- hyphae hyaline, very slightly thick-walled, smooth, simple-septate, frequently branched, 2.8-3.5um in diam., mostly empty, sometimes collapsed (Fig. 12).

CULTURE EXAMINED: Polysporous culture from basidiocarp- BRCMH C-881 (Holotype). The culture has been deposited at ATCC (ATCC# 76508).

SPECIES CODE: 1.6.7.32.36.40.44.53.54[following the system of Nobles(1965)]

Figs.1-6. *Phanerochaete citri* (holotyte): 1.basidiocarp; 2.basidium; 3.basidiospores; 4.growth on malt extract agar after 6 weeks; 5.growth on gallic acid agar after 2 weeks; 6.growth on tannic acid agar after 2 weeks.


10 µm

DISCUSSION

From the foregoing description it is evident that *Phanerochaete citri* fits very well into the *Phanerochaete tuberculata* group (= subg. *Phanericium* Parm.) of the genus *Phanerochaete* Karst. as treated by Eriksson et al. (1978).

It is distinct from any known species of *Phanerochaete* Karst. by the following features: (i) basidiocarp with indeterminate margin and smooth hymenial surface which turns black in 2% KOH; (ii) hyphae hyaline, thin-walled, smooth and simple-septate; (iii) cystidia absent; (iv) in 1.5% malt extract agar medium growth rapid, sodden and appressed; (v) gives negative result in oxidase test.

It may be mentioned here that *P. citri* shows close similarity with two species of *Phanerochaete* namely, *Phanerochaete tuberculata* (Karst.) Parm. and *Phanerochaete xerophila* Burdsall. But *P. tuberculata* possesses tuberculate hymenial surface (Rattan 1977) with rhizomorphic margin and some of its hyphae are nodose-septate (Eriksson et al. 1978) whereas in *P. citri* the basidiocarp is characterised by smooth hymenial surface with indeterminate margin and the hyphae are always simple-septate. *P. citri* differs from *P. xerophila* (Burdsall 1985) in the lack of densely cracked hymenial surface and encrusted hyphae.

Ecologically these three species (*P. xerophila*, *P. tuberculata* and *P. citri*) occupy vastly different niches. *P. xerophila* is distributed in much drier region of USA, *P. tuberculata* occurs at higher and cooler regions of different countries but *P. citri* has been collected from planes of India where the climate is somewhat warmer and much humid.

Considering its hymenial, hyphal and ecological features it can be easily concluded that *P. citri* is distinct from any known species of *Phanerochaete*. Hence, it is described here as new species.

ACKNOWLEDGEMENTS

The author is greatly indebted to Dr. H.H.Burdsall,Jr.,Center for Forest Mycology Research, Forest Products Laboratory,Madison,Wisconsin,USA for confirming the identification. The author is also indebted to Dr.J.Boidin,17 Rue Duguesclin, 69006 LYON, France for critically reviewing the manuscript.

Figs.7-12. *Phanerochaete citri* (holotype). 7-9. Microscopic structures from basidiocarp: 7. hyphae; 8. basidia; 9. basidiospores. 10-12. Microscopic structures from culture: 10. hyphae from advancing zone; 11. aerial hyphae; 12. submerged hyphae.

REFERENCES

Burdsall,H.H.,Jr.1985. A contribution to the taxonomy of the genus Phanerochaete (Corticiaceae,Aphyllophorales). Mycologia Memoir No.10. 165p. J.Cramer Publ.,Germany.

Eriksson,J.,K.Hjortstam and L.Ryvarden. 1978. The Corticiaceae of North Europe. Vol.5. Fungiflora, Oslo, Norway.

Nobles,M.K. 1965. Identification of cultures of wood-inhabiting Hymenomycetes. Can.J.Bot. 43 : 1097-1139.

Rattan,S.S. 1977. The resupinate Aphyllophorales of the North Western Himalayas. J.Cramer, Vaduz, Germany.

MYCOTAXON

Volume XLII, pp. 35-41 October-December 1991

THE NEW SOUTHERN HEMISPHERE LICHEN GENUS COELOPOGON (LECANORALES, ASCOMYCOTINA), WITH A NEW SPECIES FROM SOUTHERN AFRICA

FRANKLIN A. BRUSSE* & INGVAR KÄRNEFELT**

**National Botanical Institute, Private Bag X101, Pretoria, SOUTH AFRICA.*
***Department of Systematic Botany, University of Lund,*
S-223 61 Lund, SWEDEN.

ABSTRACT

A new genus *Coelopogon* Brusse & Kärnef. (Ascomycotina, Lecanorales) is described. It is presently known from southern South America and southern Africa. One new species is described, *Coelopogon abraxas* Brusse. One new combination is made, *Coelopogon epiphorellus* (Nyl.) Brusse & Kärnef. The close affinity of these two species is discussed, as is the unusual chemistry. The separation of *Coelopogon* from the presumptive related *Coelocaulon* is discussed and a cladistic analysis of the associated groups is presented.

Coelopogon Brusse & Kärnef., *gen. nov.*

Thallus fruticosus, corticola vel detriticola. *Rami* anisotome dichotomi, foveolati. *Cortex* monostratus, chondroideus, pseudocyphellis destitutus. *Cavitas medullosa* alba, hyphis longistrorsum periclinalibus, fasciculatis. *Apothecia* et *pycnidia* ignota. *Thallus* acidum epiphorellicum 1 et acidum epiphorellicum 2 continens.

TYPUS. --- *Coelopogon abraxas* Brusse

Thallus fruticose, corticolous or detriticolous. *Branches* anisotomic dichotomous, foveolate. *Cortex* one-layered, chondroid, pseudocyphellae lacking. *Medullary cavity* white, hyphae longitudinally periclinal, fascicled. *Apothecia* and *pycnidia* unknown. *Chemistry*: Epiphorellic acids 1 & 2 present.

This new genus has previously been treated under *Coelocaulon* Link (Kärnefelt 1986), and indeed was regarded as rather isolated within the genus. The two genera are in fact distinct on several morphological characters. Firstly, the cortex of *Coelopogon* is single-layered, and is chondroid, with the cell lumina of the heavily gelatinized hyphae barely discernible. The cortex of *Coelocaulon*, on the other hand, is two-layered, with the outer layer paraplectenchymatous, being composed of isodiametric cells, with not too heavily thickened walls. In this regard, *Coelocaulon* shows an affinity to *Cetraria*. *Coelocaulon*, in addition, has a second (inner) and thicker cortical layer, consisting of longitudinal hyphae which are gelatinized. This second, inner cortical layer is missing in *Coelopogon*. The cortex of *Bryoria*, consists solely of gelatinized, longitudinal hyphae, similar to the inner layer of the cortex of *Coelocaulon*. It is interesting to note, that the medulla of *Coelopogon* consists of bundles of longitudinal hyphae, resembling the inner cortex of *Coelocaulon*, so that the former may be related to the latter, but the medulla of *Coelopogon* just represents a more degenerate state of the inner cortex of *Coelocaulon*. The two genera are nevertheless amply distinct by the above mentioned difference in the (outer) cortex.

Secondly, all species of *Coelocaulon* have pseudocyphellae (Kärnefelt 1986), whereas both *Coelopogon* species lack pseudocyphellae. This character again points to a relationship between *Coelocaulon* and *Cetraria*, and alienates *Coelopogon*. Thirdly the medulla of *Coelopogon* is composed of bundles of longitudinal hyphae (which may represent a degenerate inner cortical layer or not), whereas that of *Coelocaulon* is composed of randomly and laxly arranged hyphae (loose plectenchyma), which show no tendency to aggregate into bundles. Fourthly, *Coelopogon* has clustered isidia, whereas *Coelocaulon* is non-isidiate. Lastly, *Coelopogon* species are mainly corticolous or detriticolous, whereas those of *Coelocaulon* are chiefly terricolous.

Unfortunately, apothecia of this new genus have never been found, so that it is hard to make any definite statements on the relationships of *Coelopogon*. Pycnidia have also not been observed, which is even more remarkable, since pycnidia placed terminally on projections similar to the species within *Cetraria*, are quite frequent in all *Coelocaulon* species (Kärnefelt 1986).

The chemistry of *Coelopogon* also differs from *Coelocaulon*, in that the former contains peculiar depsidone equivalents, whereas *Coelocaulon* contains only aliphatic lactone acids. Of the depsidone equivalents in *Coelopogon*, epiphorellic acid 1 is the least peculiar, and can be considered to be a methanolysis product of norcolensoic acid (Elix & Jenie 1989, Fiedler *et al*. 1986). However, epiphorellic acid 2 is highly unusual, because it has a keto group in the C_3 position of one of the pentyl side chains. This C_3 keto group is not consistent with a polyketide origin of this substance, and thus additional enzymatic steps would be required to emplace it in a biosynthetic pathway (Comber *et al*. 1989, Fiedler *et al*. 1986). The only other lichen substance with this characteristic is the depside miriquidic acid (and normiriquidic acid). In fact, epiphorellic acid 2 can be thought of as the methanolysis product of the unknown (in nature) depsidone corresponding to normiriquidic acid, which might be called normiriquidonic acid. Thus epiphorellic acid 2 is a derivative of the depsidone corresponding to normiriquidic acid. This unusual chemistry further supports the enstatement of a new genus for the two species under discussion.

In conclusion, the morphological, anatomical, and unique chemical characteristics, suggest that the studied material is well separated from the genus *Coelocaulon*. A cladistic analysis based on 20 different characters, with *Cornicularia* chosen as out-group, also strongly supports the separation of the new genus from *Coelocaulon* (Fig. 1). The states of all the characters listed below are negative for the out-group *Cornicularia*. The internal cortex is extremely thick and composed of highly gelatinized hyphae. The medulla mainly consists of rather dense hyphae. No secondary metabolites are present. The saxicolous, blackish, mainly dull lobes, are slightly flattened and strongly cartilaginous, and lack pseudocyphellae, isidia and soralia (Kärnefelt 1986).

List of apomorphic characters studied:

1. Internal cortical layer composed of longitudinal hyphae.
2. Medulla consists of characteristic strands.
3. Lichesterinic acid present.
4. Protolichesterinic acid present.
5. Norstictic acid present.
6. Epiphorellic acid 1 present.
7. Epiphorellic acid 2 present.
8. Lobes with distinctive foveolate surface.
9. Lobes with rather small pseudocyphellae.
10. Lobes with rather large conspicuous pseudocyphellae.
11. Erect corticolous sterile lobes.
12. Erect terricolous mainly fertile lobes.
13. Terete to angular lobe portions.
14. Brownish lobe segments.
15. Glossy lobe surface.
16. Pycnidia placed terminally on projections present.
17. Clustered isidia present.
18. Soralia sprouting isidia present.
19. Terricolous.
20. Corticolous or detriticolous.

```
Input data matrix

                                         1 1 1 1 1 1 1 1 1 1 2
Taxon                 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0
-------------------------------------------------------------
Cornicularia          0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
Coelopogon   abra     0 1 0 0 0 1 1 1 0 0 0 0 1 1 1 0 1 1 0 1
Coelopogon   epih     0 1 0 0 0 1 1 1 0 0 0 0 1 1 1 0 1 0 0 1
Coelocaulon ac        1 0 1 1 0 0 0 0 0 1 0 1 1 1 1 1 0 0 1 0
Coelocaulon cre       1 0 1 1 0 0 0 0 0 1 1 0 1 1 1 1 0 0 0 1
Coelocaulon mur       1 0 1 1 0 0 0 0 1 0 0 1 1 1 1 1 0 0 1 0
Coelocaulon step      1 0 1 1 1 0 0 0 0 1 0 1 1 1 1 1 0 0 1 0
```

Table 1. --- Data matrix and terminal taxa corresponding to cladogram in fig. 1.

Coelopogon abraxas Brusse, *sp. nov.*

Thallus fruticosus, caespitosus, usque ad 10 cm diametro, super *Bryomorphe lycopodioidem* crescens. *Rami* anisotome dichotomi, interdum contorti, interdum longistrorsum costati, usque ad 1 mm diametris. *Superficies* nitida, pallide brunnea

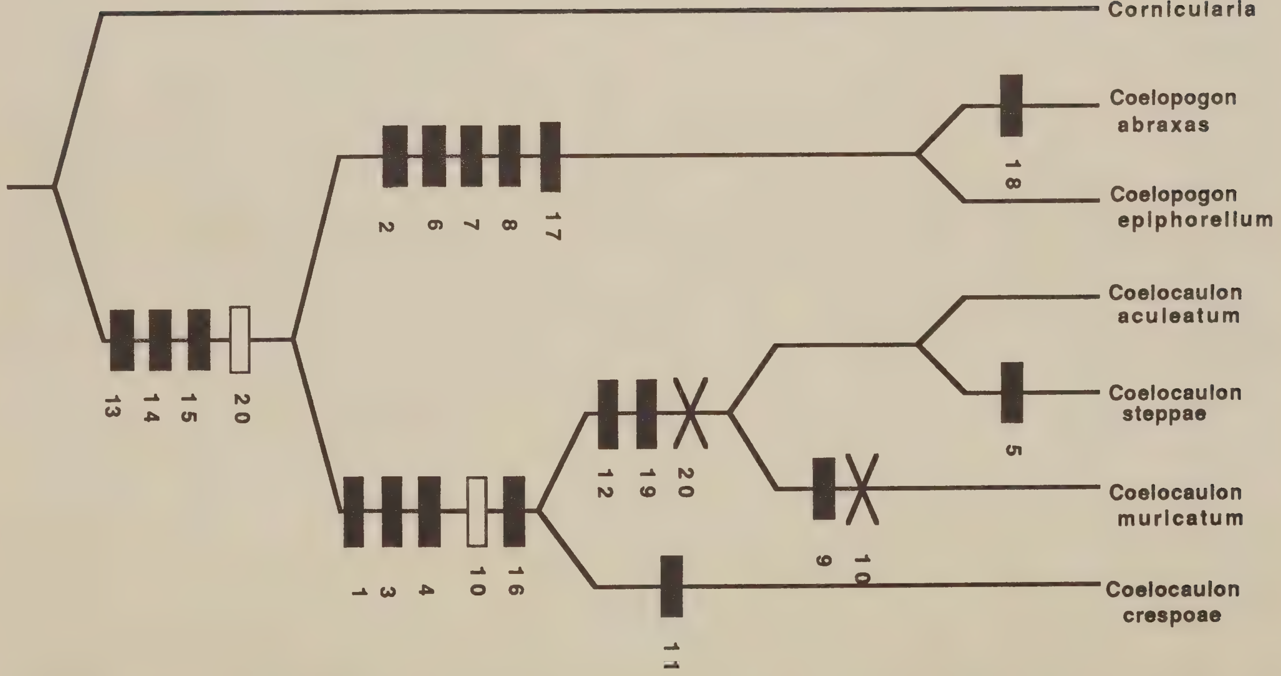

Cornicularia
Coelopogon abraxas
Coelopogon epiphorellum
Coelocaulon aculeatum
Coelocaulon steppae
Coelocaulon muricatum
Coelocaulon crespoae
13
14
15
20
2
6
7
8
17
18
1
3
4
10
16
12
19
20
11
5
9
10

FIGURE 1. - One of two equally parsimonious cladograms received from the data in table 1. Character numbers and terminal taxa correspond with text. Filled square = synapomorphy; open square = synapomorphy with later reversal; X = reversal.

vel brunnea, undulata vel foveolata, soraliata, non vere spinulosa, epicortice non poroso (continuo). *Soralia* primum brunnea dein alba, cum isidiis instructa, usque ad 1 mm diametris, leviter elevata. *Soredia* granularia, 30 - 70 µm diametris. *Cortex* chondroideus, 25 - 35 µm crassus. *Apothecia* et *pycnidia* non visa. *Thallus* acidum epiphorellicum 1 continens.

TYPUS: SOUTH AFRICA, CAPE PROVINCE - **3319** (Worcester): Summit of Jona's Kop in the Riviersonderend Mountains near Villiersdorp. Growing over the small cushion plant, *Bryomorphe lycopodioides* (Sch. Bip.) Levyns, growing in rock crevices on S Table Mountain Sandstone cliffs. Alt. 1620 m (-**DC**). *F. Brusse 5447*, 20. iii. 1988 (**PRE**, holo-; **BM**, **LD**, iso-). Figurae 2 et 3.

Thallus fruticose, caespitose, up to 10 cm across, growing over the small cushion plant *Bryomorphe lycopodioides*, growing in rock crevices on south facing sandstone cliffs. *Branches* anisotomic dichotomous, sometimes contorted, sometimes ribbed, up to 1 mm diam. *Surface* glossy, pale brown to brown, undulate to foveolate, soraliate, not truely spinulose; epicortex not pored (continuous). *Soralia* at first brown becoming white with age, up to 1 mm across (longer by confluence), bearing isidia, slightly raised. *Soredia* granular, 30 - 70 µm diam. *Cortex* chondroid, 25 - 35 µm thick. *Apothecia* and *pycnidia* not seen. *Chemistry*: Epiphorellic acid 1 present.

This new species is closely related to *Coelopogon epiphorellus* (Nyl.) Brusse & Kärnef.*, but is granular sorediate sprouting isidia, rather than clustered coralloid isidiate (Kärnefelt 1986). The isidia of *C. abraxas* taper to the apex, and can be termed acute (fig. 3), whereas those of *C. epiphorellus* are abruptly rounded at the apex, and can be termed obtuse or stumpy (Kärnefelt 1986, fig. 35D). The chemistry of these two species is the same, containing varying proportions of epiphorellic acids 1 and 2. Although Hawksworth & Moore (1969) reported lichesterinic and protolichesterinic acids in *C. epiphorellus*, this could not be confirmed by the present authors. Both *C. epiphorellus* and *C. abraxas* contain the same series of aliphatic acids, which seem closer to caperatic acid in TLC behavior, in addition to the epiphorellic acids.

At present, this new species is known only from the type locality, the summit of Jona's Kop in the Riviersonderend Mountains near Villiersdorp.

ACKNOWLEDGEMENTS

Thanks are extended to Dr. I.M. Brodo for reviewing this paper and to Dr. J.A. Elix for determining the chemistry. We are also grateful to Mrs. A.J. Romanowski for the photography.

---

* **Coelopogon epiphorellus** (Nyl.) Brusse & Kärnef., *comb. nov.* Basionym: *Cetraria epiphorella* Nyl. in Crombie, J. Linn. Soc. **15**: 227. 1876.

LITERATURE CITED

COMBER, M.F., SARGENT, M.V., SKELTON, B.W. & WHITE, A.H. 1989. Depsidone Synthesis. Part 24. The Synthesis of Epiphorellic Acid 2. A Pseudodepsidone and X-ray Crystal Structure of a Grisadienedione Epoxide. *Journal of the Chemical Society, Perkin Transactions 1*, **1989**: 441 - 448.

ELIX, J.A. & JENIE, U.A. 1989. A Synthesis of the Lichen Diphenyl Ether Epiphorellic Acid 1. *Australian Journal of Chemistry* **42**: 987 - 994.

FIEDLER, P., GAMBARO, V., GARBARINO, J.A. & QUILHOT, W. 1986. Epiphorellic Acids 1 and 2, Two Diaryl Ethers from the Lichen *Cornicularia epiphorella*. *Phytochemistry* **25**: 461 - 465.

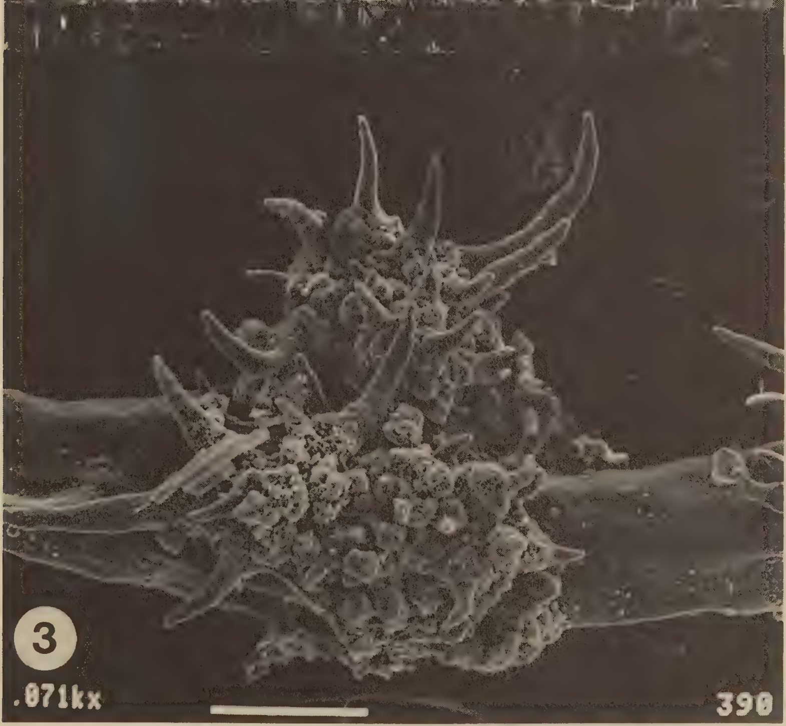
HAWKSWORTH, D.L. & MOORE, D.M. 1969. Some lichens from Tierra del Fuego, with notes on their chemical constituents. *Bryologist* **72**: 247 - 251.

KÄRNEFELT, I. 1986. The genera *Bryocaulon*, *Coelocaulon* and *Cornicularia* and formerly associated taxa. *Opera Botanica* **86**: 1 - 90.

FIGURE 2. - *Coelopogon abraxas* Brusse, habit. *F. Brusse 5447*, holotype. Scale in mm.

FIGURE 3. - *Coelopogon abraxas* Brusse, scanning electron micrograph of a portion of a branch showing a soralium sprouting isidia (actually two soralia close together). *F. Brusse 5447*, holotype. Bar = 0.28 mm.

2



3

MYCOTAXON

Volume XLII, pp.43-52 October-December 1991

A NOMENCLATURAL SYNOPSIS OF *SEPTOSPERMA* (CHYTRIDIOMYCETES) AND EMENDATION OF *S. RHIZOPHYDII*

WILL H. BLACKWELL AND MARTHA J. POWELL

Department of Botany, Miami University, Oxford, Ohio 45056

ABSTRACT

The nomenclature of *Septosperma* (Chytridiomycetes) is reviewed involving typification, gender, and author citation. A nomenclatural revision is presented, and the description of *S. rhizophydii* Whiffen *ex* Seymour is emended to include recent observations on resting spore characters.

Since the initial publication of the generic name *Septosperma* (Whiffen 1942), nomenclatural problems have existed with and within this taxon, which workers (Seymour 1971; Milanez 1974) have tried to solve but for which not all problems have been addressed or resolved. Whiffen (1942) erected *Septosperma* for chytrid species with distinctive two-celled, columnar resting spores. However, Whiffen failed to validate either her new genus or the accompanying new species, *S. rhizophidii*, with a Latin diagnosis as required by the *International Code of Botanical Nomenclature* (ICBN) since 1935 (Greuter *et al.* 1988, cf. Article 36), in effect leaving these names nomenclaturally invalid for almost 30 years (Seymour 1971). Whiffen's transfer of *Phlyctidium anomalum* Couch (1932) to *Septosperma* as a new combination, *S. anomala* (Couch) Whiffen (1942), was also invalid since the generic name, *Septosperma*, technically could not exist without a Latin diagnosis. A binomial such as *Septosperma anomala* Whiffen, cannot be considered to be validly published if the name of the genus to which it was assigned was invalid at the time of publication (see Article 43, ICBN). The only solution to the dilemma was subsequent validation of the generic name, and new species described with the genus, and appropriate transfer of other previously valid species names as necessary.

Seymour (1971) thus eventually validated the generic name *Septosperma* with a Latin description, and hence the correct citation of the genus name is *Septosperma* Whiffen *ex* Seymour, or simply *Septosperma* Seymour (cf. Article 46.3, ICBN). By transferring the type, *S. anomala* (Couch) Whiffen *ex* Seymour, under the validated generic name (the basionym *Phlyctidium anomalum* Couch already being validly published) and by providing a Latin description for *S. rhizophidii*, Seymour (1971) also validated these binomials in *Septosperma*..

As for other species names attributed to *Septosperma*, *S. multiforma* Canter (1963) and *S. spinosa* Willoughby (1965) were published with Latin descriptions prior to Seymour's validation of the generic name; consequently, these binomials were also nomenclaturally invalid. Milanez (1974) observed that Seymour (1971) had not listed these latter species, and accordingly did so himself. Milanez's verbatim repetition of Canter's and of Willoughby's Latin descriptions, under the by then valid generic name (*Septosperma* Whiffen *ex* Seymour 1971), finally validated *Septosperma multiforma* Canter *ex* Milanez and *S. spinosa* Willoughby *ex* Milanez (Milanez 1974). We think that Milanez meant to refer to these names as *nomina invalida* and accidentally called them *nomina nuda*.

An additional binomial under *Septosperma*, *S. irregularis* (Karling) Dogma (1974), based on *Asterophlyctis irregularis* Karling (1967), is without nomenclatural complication, except for the question of the ending of the specific epithet (addressed subsequently).

Despite the contributions of these studies to the taxonomy, nomenclature and biological understanding of *Septosperma*, several nomenclatural problems remain in this genus. The first of these deals with the designation or citation of types. Article 37 of the ICBN requires citation (on or after January 1, 1958) of the holotype for proper validation of a new name at the rank of genus or below (Greuter *et al.* 1988). Whiffen (1942) would not have been required by the edition of ICBN operative during 1942 to identify the type of the genus or of the new species she described. Whether she in fact did so or not is moot to the nomenclature since she, as indicated, did not provide Latin diagnoses. Seymour (1971) appropriately designated *S. anomala* (technically, its type) as the type of the generic name *Septosperma*, a fact not noted in *Index Nominum Genericorum* (Farr *et al.* 1979).

Seymour did not explicitly provide type citation of *S. rhizophidii*, although his reference to Whiffen's Figures 28-31 and 33-52 could be interpreted (as we are so doing) to accomplish this (see Article 37.3, ICBN) in effect. We are herewith refining this citation of figures (as holotype) to Whiffen's drawings comprising Figures 33-50 (Whiffen 1942) to serve as the type, in accordance with the provisions of Article 9 of ICBN. We make this suggestion because Figures 51-52 on this plate are exclusively of the host (*Rhizophydium macrosporum* Karling) and should not be included as a component of the type *per se*. Also, we do not favor the inclusion of Figures 28-31 because, although not inappropriate, they are not a part of the plate containing Figures 33-50. In this regard, note the intent of Articles 9 (especially 9.3) and 37.3 in allowing the designation of an (a single) illustration for service as the type, when no type specimen exists. Figures 33-50 are line drawings, whereas Figures 28 through 31 constitute a portion of a separate photographic plate (containing also photographs of a different organism).

Because *S. anomala* (Couch) Whiffen *ex* Seymour is a new combination based on a 1932 basionym and not a name of a new taxon, Seymour (1971) was not required by ICBN to cite a type for his combination. However, he listed, as illustrations of *S. anomala*, Couch's (1932) Figures 69-83 and Whiffen's (1942) Figures 28-31 and 33-52. Since Whiffen's figures are of *Septosperma rhizophidii* and of *Rhizophydium macrosporum*, and not of *Septosperma anomala*, only Couch's (1932) Figures 69-83 of *Phlyctidium anomalum* should have been listed for *Septosperma anomala*.

As a final minor notation on typification, when Milanez (1974) validated *Septosperma spinosa* Willoughby *ex* Milanez, he incorrectly referred to Willoughby's type as "F.B.A.S." Instead, it should have been "F.B.A.8" (i.e., the "S" should be "8") as in the original publication (Willoughby 1965). "F.B.A." apparently is the abbreviation of "Freshwater Biological Association," Ambleside,Westmorland (United Kingdom).

Another nomenclatural problem relates to the gender of the generic name *Septosperma* and the endings of the specific epithets recognized. The genus name is based on *septum*, Latin for fence, and *sperma*, Greek for seed. Being a compound name, the gender of *Septosperma* is determined by the second half of the name, i.e., *sperma* (q.v.: Stearn 1983; ICBN 1988, Article 76.2). Although *sperma* appears to be a feminine Latin noun, it is actually a Greek neuter noun, retaining its original gender when transcribed to Latin. Stearn (1983) explicitly indicates that generic names (nouns) ending in -*sperma* are to be treated as neuter. Both roots of the generic name (*septum* and *sperma*) are, in fact, neuter; thus, *Septosperma* is unequivocally a neuter name. Article 23.5 of the ICBN requires grammatical agreement of the specific epithet, when it is adjectival in form and not used as a substantive, with the generic name. Adjectival specific epithets of feminine ending in *Septosperma* were doubtless based on the erroneous belief that *Septosperma* was a feminine noun. Although not invalid when published with an incorrect termination, such epithets should be corrected (see Article 32.5, ICBN), in this case to neuter form. Under the generic name, *Septosperma*, hence, *anomala* = *anomalum*, *multiformis* (published as "*multiforma*") = *multiforme*, *spinosa* = *spinosum*, and *irregularis* = *irregulare*. With the exception of *anomalum*, these annotations are noted in various volumes of *The Index of Fungi* (Commonwealth Mycological Institute, see "Literature Cited"). Also noted in this index is the epithet *rhizophidii*, a genitive noun, as requiring alteration from *rhizophidii*, as cited by Whiffen and by Seymour, to *rhizophydii*, based on the correct spelling of the chytrid generic name *Rhizophydium* Schenk (cf. Sparrow 1960). Article 73 of the ICBN permits such orthographic corrections, although urging reserve in any alteration of original spelling. Although "rhizophidiii" was the spelling employed when this species was validly published (Seymour 1971) and was based on Whiffen's (1942) spelling , we believe "rhizophydii" to be orthographically correct, and that this orthographic change is warranted (Recommendation 73H, ICBN). Although *y* is rare in classical Latin (occurring primarily in certain words introduced from the

Greek language) and although *i* is indeed very common in Latin (serving as a vowel and for the *y* consonant sound), Article 73.4 (ICBN) states the clear permissibility of the use of *y* in Latin plant names (and many such names exist). We note in support of the use of the *y* spelling that Karling (1977) in fact employed the spelling, *Septosperma rhizophydii,* doubtless in deference to the spelling of the generic name, *Rhizophydium,* the name of the chytrid upon which this species of *Septosperma* is parasitic.

SUMMARY OF SPECIES NAMES UNDER *SEPTOSPERMA*

Septosperma anomalum (Couch) Whiffen *ex* Seymour, 1971
(*"anomala"*)
Phlyctidium anomalum Couch, 1932
Septosperma anomala (Couch) Whiffen, 1942
[*sine nom. gen. valid.*]

Septosperma rhizophydii Whiffen *ex* Seymour, 1971
(*"rhizophidii"*)
Septosperma rhizophidii Whiffen, 1942
[*sine diagn. lat.*]

Septosperma multiforme Canter *ex* Milanez, 1974
(*"multiforma"*)
Septosperma multiforma Canter, 1963
[*sine nom. gen. valid.*]

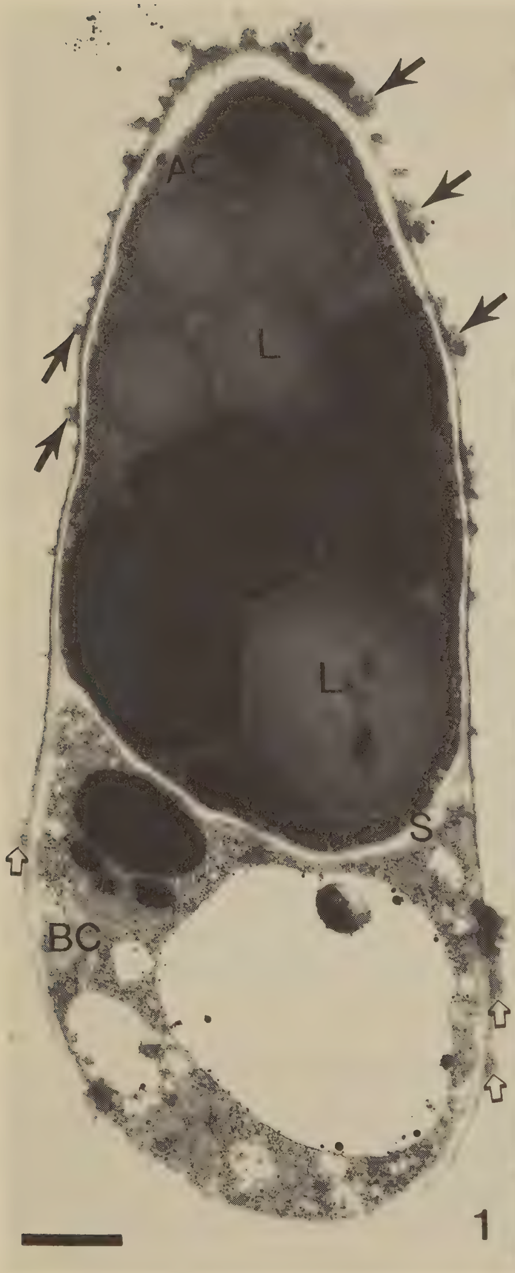
Septosperma spinosum Willoughby *ex* Milanez, 1974
(*"spinosa"*)
Septosperma spinosa Willoughby, 1965
[*sine nom. gen. valid.*]

Septosperma irregulare (Karling) Dogma, 1974
(*"irregularis"*)
Asterophlyctis irregularis Karling, 1967

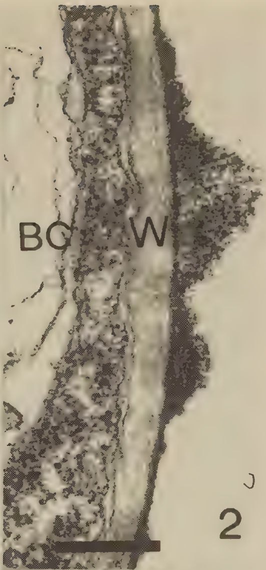
EMENDATION OF DESCRIPTION OF *SEPTOSPERMA RHIZOPHYDII*

Since Seymour's (1971) validation of *Septosperma,* additional observations have been made which are important to the understanding of *S. rhizophydii.* Karling (1977) discovered that the resting spore serves as a prosporangium when it germinates, producing a sporangium-like structure in which zoospores are cleaved (Karling 1977; fig. 13, pg. 79). In a scanning electron microscopic study of *S. rhizophydii,* Zattau (1981) observed tubercles scattered on the upper portion of the resting spore. Because the micrographs were at relatively low magnifications, additional details of the tubercles could not be determined. More recently Powell and Blackwell (1991) found with transmission electron microscopy that tubercles are densely scattered over the surface of the apical cell of the mature resting spore (two-celled stage) of *S. rhizophydii,* and a portion of the basal cell adjacent to the apical cell (Fig. 1). These tiny tubercles were visible with light microscopy (Powell and Blackwell 1991) and range in size from 0.1-0.4 µm in diameter and 0.2-0.3 µm long. The outer wall layer is a thin rind from which the tubercles on the basal cell project (Fig. 2). In contrast the upper cell tubercles include projections of the inner wall layer, covered by the outer-rind layer and a loosely fibrillar coat (Fig. 3). Observation of tubercles on the resting spore of *S. rhizophydii* means that of the five species of *Septosperma,* four have either ornamented or lobed resting spores.

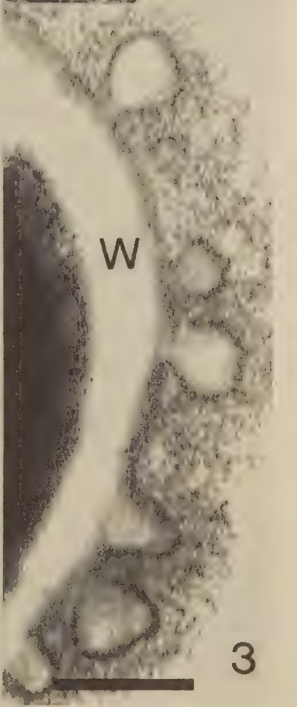
FIGURES 1-3. *Septosperma rhizophydii.* 1. Septum (S) separates the apical cell (AC) from the basal cell (BC) in a mature, two-celled resting spore. The apical cell (AC) is filled with lipid globules (L) and covered with tubercles (solid arrows). Notice a few tubercles (open arrows) on the basal cell (BC), scale = 0.5 µm. 2. Detail of wall (W) of basal cell (BC) with tubercles showing continuity with the thin outer wall layer, scale = 0.25 µm. 3. Detail of apical cell wall (W) with tubercles. Notice that the tubercles consist of the electron-lucent inner cell wall layer and the thinner, outer electron-dense wall layer, which is coated with fibrillar material, scale = 0.25 µm.



1



2



3

Thus, resting spores of *S. anomalum* have smooth surfaces (Couch 1932), those of *S. rhizophydii* are finely tuberculated, those of *S. spinosum* have spines up to 2.5 µm long (Willoughby 1965), those of *S. multiforme* have irregular papillations on the outer wall (Canter 1963), and those of *S. irregulare* have lobed extensions of the cytoplasm (Karling 1967). Although Dogma (1974) noted the similarity between resting spores of *S. irregulare* and the highly variable species *S. multiforme*, zoosporangia of these two species are quite distinctive because of the absence of the pegs on zoosporangia of *S. multiforme* which are so prominent on the zoosporangia of *S. irregulare.* These recent observations on surface features of resting spores of *Septosperma* make Milanez's (1974) key to species of the genus obsolete. The following emended description is based on that of Seymour (1971), with Karling's (1977), Zattau's (1981) and our observations added in italics.

Septosperma rhizophydii Whiffen *ex* Seymour, *Mycologia* 63: 91. 1971, emendavit.

Sporangium sessile or stalked; spherical to pyrifom, rarely ellipsoidal; smooth-walled; 4.2-32.3 µm in diameter; haustorium peg-like or bulbous. Planonts spherical or subspherical; 1.6-3 µm in diameter; with single glistening droplet; discharge effected through 1-3 apical or lateral pores. Resting spores sessile or stalked; clavate to broadly cylindrical, rarely ellipsoidal; 4.8-36.2 X 3.2-16.1 µm; mature resting spore thick-walled, *two-celled, with apical cell and upper portion of basal cell covered by tubercles 0.1-0.4 µm in diameter and 0.2-0.3 µm long.* Resting spore *functioning as a prosporangium at germination. Parasite on zoosporangia of Chytridiomycetes.*

ACKNOWLEDGEMENTS

We are indepted to Dr. Terry Johnson, Jr., Botany Department, Duke University; Dr. Donald Barr, Biosystematics Research Institute, Ottawa; and Dr. Dan Nicolson, Department of Botany, Smithsonian Institution for critical review of this manuscript.

LITERATURE CITED

CANTER, H. M. 1963. Studies on British chytrids XXIII. New species on chrysophycean algae. Trans Brit. Mycol. Soc. 46: 305-320.

COUCH, J.N. 1932. *Rhizophidium, Phlyctochytrium* and *Phlyctidium* in the United States. J. Elisha Mitchell Sci. Soc. 47: 245-260.

DOGMA, I. J., JR. 1974. Studies on chitinophilic *Siphonaria, Diplophlyctis,* and *Rhizoclosmatium,* Chytridiales. II. *Asterophlyctis sacroptoides* H.E. Petersen: A *Diplophlyctis* with a sexual phase. Nova Hedwigia 25: 121-141.

FARR, E. R., J. A. LEUSSINK and F. A. STAFLEU. 1979. Index Nominum Genericorum (Plantarum) 3: 1604. Regnum Vegetabile Vol. 102: 1277-1896 p.

GREUTER, W., H. M. BURDET, W. G. CHALONER, V. DEMOULIN, R. GROLLE, D. L. HAWKSWORTH, D. H. NICOLSON, P. C. SILVA, F. A. STAFLEU, E. G. VOSS and J. McNEIL. 1988. International Code of Botanical Nomenclature (Adopted by the Fourteenth International Botanical Congress, Berlin, July-August 1987). Regnum Vegetabile 118: xiv + 328 p.

INDEX OF FUNGI. 1940-present. Commonwealth Mycological Institute, Kew, Surrey: Vol. 3(8), correction to *Septosperma "multiforme;"* Vol. 3(13), correction to *Septosperma "spinosum;"* Vol. 4(3), correction to *Septosperma "rhizophydii;"* indication of *S. "anomala"* as the "type species" of *Septosperma;* Vol. 4(10), correction to *Septosperma "irregulare."*

KARLING, J. S. 1967. Some zoosporic fungi of New Zealand. V. Species of *Asterophlyctis, Obelidium, Rhizoclosmatium, Siphonaria* and *Rhizophlyctis.* Sydowia, Ann. Mycol. Ser. 2. 20: 96-108.

KARLING, J. S. 1977. Chytridiomycetarum Iconographia. J. Cramer (Lubrecht & Cramer), Monticello, New York. xiii + 414 p.

MILANEZ, A. I. 1974. Notes on the genus *Septosperma* Whiffen *ex* Seymour. Rickia 6: 63-70.

POWELL, M. J. and W. H. BLACKWELL. 1991. A proposed dispersal mechanism for *Septosperma rhizophydii.* Mycologia (in press).

SEYMOUR, R. L. 1971. Studies on mycoparasitic chytrids. I. The genus *Septosperma.* Mycologia 63: 83-93.

SPARROW, F. K. 1960. Aquatic Phycomycetes, 2nd rev. ed. Univ. Michigan Press, Ann Arbor. xxv + 1187 p.

STEARN, W. T. 1983. Botanical Latin, 3rd ed. David & Charles Publishers, Newton Abbot, Great Britain. xiv + 566 p.

WHIFFEN, A. J. 1942. Two new chytrid genera. Mycologia 34: 543-557.

WILLOUGHBY, L. G. 1965. A study of Chytridiales from Victorian and other Australian Soils. Arch. Mikrobiol. 52: 101-131.

ZATTAU, W.C. 1981. Topographic features of chytrids collected from a sphagnum bog. Mycologia 73: 1189-1194.

MYCOTAXON

Volume XLII, pp. 53-61 October-December 1991

NOTES ON COELOMYCETES. IV. PHYLLOSTICTA ANDROPOGONIVORA, CAUSAL ORGANISM OF LEAFSPOT DISEASE OF SCHIZACHYRIUM SCOPARIUM (LITTLE BLUESTEM) AND ANDROPOGON GERARDII (BIG AND SAND BLUESTEM), RECLASSIFIED IN ASCOCHYTA.

GARETH MORGAN-JONES and MICHELE R. OWSLEY

Department of Plant Pathology, College of Agriculture and Alabama
Agricultural Experiment Station, Auburn University, Auburn, Alabama 36849

and

JOSEPH M. KRUPINSKY

USDA, ARS, Northern Great Plains Research Laboratory,
Mandan, North Dakota 58554

ABSTRACT

Phyllosticta andropogonivora Sprague & Rogerson, which causes a leaf spot disease of little, big and sand bluestem, has been found, following examination of type and other material, to be misclassified. Following modern generic concepts, it is better placed in *Ascochyta* Lib., and is accordingly transferred to that genus. It is described and illustrated from host specimens and *in vitro*.

INTRODUCTION

The fungus *Phyllosticta andropogonivora* was originally described by Sprague and Rogerson (1958) from living leaves of *Andropogon gerardii* Vitman (big bluestem) collected in Miami Co., Kansas. Leaf spots were said to be "reddish to brown, tardily pale in the center, sublinear to somewhat diffuse by fusion". The fungus was characterized by its capsule-shaped conidia, with prominent oil drops at each end. Conidium size was given as 14-15 x 4-5 µm. An immature, unidentified perithecial ascomycete was said to have also been found in the type collection. Our own examination of the type specimen revealed the presence of a loculoascomycete with bitunicate asci. The pseudothecia are mostly immature, but a few asci observed, containing medianly uniseptate ascospores with acute ends, indicate the fungus to be probably a species of *Didymella* Sacc. A further collection of *P. andropogonivora* was reported by Sprague (1962) from near Mentor, Minnesota, with larger conidia than in the type [14-19 x 5.5-6.5 µm]. In addition, he mentioned that a *Phyllosticta* specimen, collected on *A. gerardii* [as *Andropogon furcatus* Mühlenb.] in North Dakota

---

Alabama Agricultural Experiment Station Journal Series No. 18-912978P

earlier (Sprague, 1950), and not determined to species, was probably *P. andropogonivora* also. Following the type description, Sprague and Rogerson (1958) stated that *P. andropogonivora* is, perhaps, closest to *Phyllosticta healdii* Sprague, but differs from it in lacking linearly arranged pycnidia. The latter species was described by Sprague (1948) from a collection on *Dichanthelium languinosum* (Elliott) Gould [≡ *Panicum languinosum* Elliott] (as *Panicum huachucae* Ashe, a facultative synonym) from Valentine, Nebraska. The conidia of *P. healdii* are of a similar shape to those of *P. andropogonivora* and are also similarly guttulate, but were reported as somewhat smaller, 11-15 x 3.5-4.5 um, and slightly constricted in the middle (Sprague, 1948, 1950).

During the mid 1980's, one of us (J.M.K.) found a leaf spot disease widespread in a little bluestem [*Schizachyrium scoparium* (Michx.) Nash, ≡ *Andropogon scoparius* Michx.] nursery established at Mandan, North Dakota, from plants collected from 588 range sites in North Dakota, Minnesota and South Dakota (Krupinsky and Tober, 1990). Discrete to coalescing leaf spots were amphigenous, reddish to brown with dark margins and light brown to tan centers. Pycnidia were sparsely scattered on lesion centers on the upper leaf surface. When diseased leaves were incubated on water agar under continuous light at 20C, numerous pycnidia covered the leaf surface within a week. Little bluestem is an important warm season, perennial bunchgrass widely distributed in the Great Plains, particularly in western, drier areas. Early vegetative growth is grazed by livestock, and the grass, because it grows on a range of soils, is considered valuable for erosion control. *Phyllosticta andropogonivora* was consistently isolated from leaves showing leaf spot symptoms (Krupinsky and Tober, loc. cit.). The fungus was also isolated from nursery and native prairie big bluestem [*Andropogon gerardii*] and from nursery sand bluestem [*Andropogon gerardii* var. *paucipilus* (Nash) Fern, = *Andropogon hallii* Hack.]. It had not previously been known to occur on little bluestem or sand bluestem. In greenhouse inoculation experiments, *P. androgononivora* was pathogenic to all three hosts, and it is thought that the fungus has potential to reduce forage quality and yield. Individual isolates caused more severe disease symptoms on their host of origin than when cross-inoculated onto both of the others.

Study of this fungus *in vitro* and *in vivo*, including examination of its type specimen, has revealed that it is not satisfactorily classified in *Phyllosticta* Pers. as defined by van der Aa (1973). In that treatment, the genus was recharacterized, based on its type species *P. cruenta* (Kunze) Kickx (Donk, 1968). This resulted in the recognition of a need to exclude from the genus the vast majority of literally hundreds of species previously classified in it. Such species, many leaf-inhabiting counterparts of *Phoma* Sacc., belong mainly to the genera *Ascochyta* Lib., *Asteromella* Pass. & Thum., *Phomopsis* (Sacc.) Sacc., as well as *Phoma* and others. A revision of those to be excluded and needing to be nomenclaturally transferred has yet to be published, however. The species presently accepted in *Phyllosticta*, because they are considered to be congeneric with *P. cruenta*, include fungi previously classified in *Phyllostictina* Sydow, which was monographed by Petrak and Sydow (1927), and *Caudophoma* Patil & Thirumalachar, both of which are now considered to be synonyms. These are characterized by one-celled, globose or broadly ellipsoid to obovoid conidia, produced holoblastically, surrounded by a slime layer and bearing an apical appendage (see van der Aa, 1973; Punithalingam, 1974). They are macroconidial anamorphs of the bitunicate ascomycete genus *Guignardia* Viala & Ravaz. (microconidial states = *Leptodothiorella* spp.).

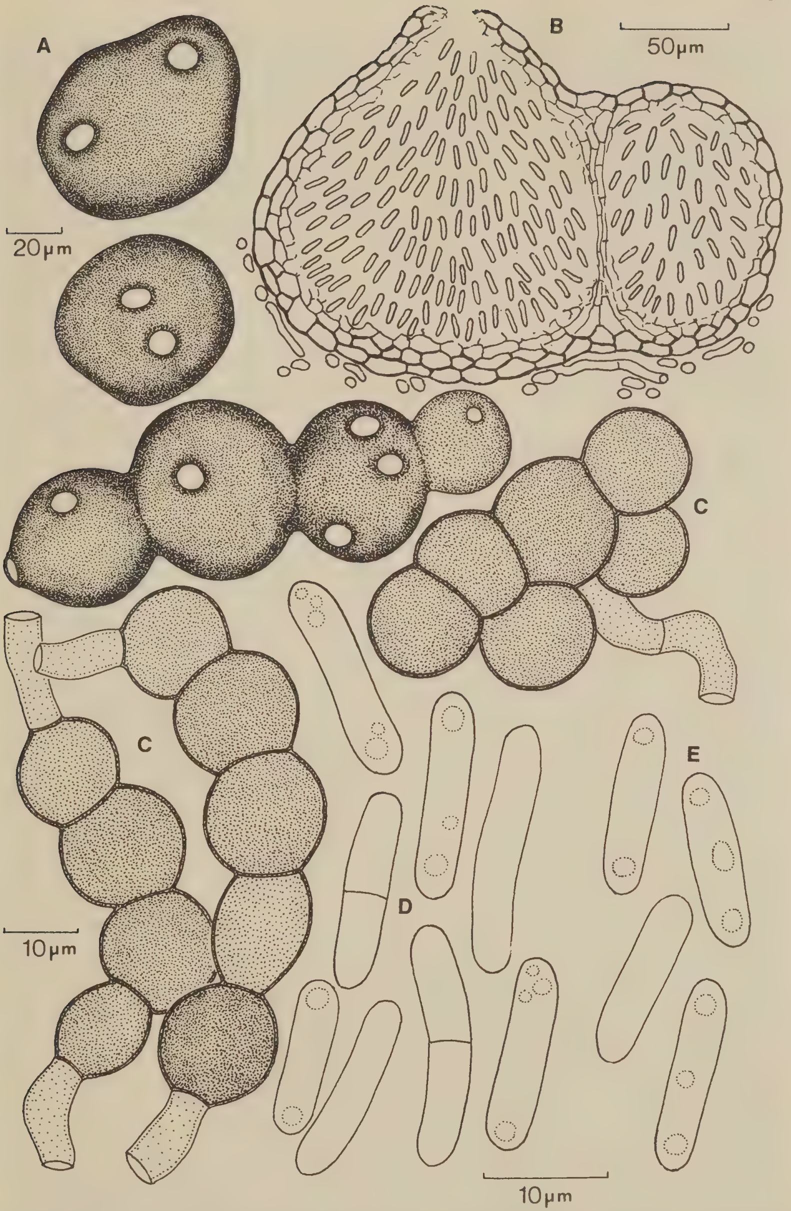

A
B
50μm
20μm
C
C
10μm
D
E
10μm

FIGURE 1. *Ascochyta andropogonivora.* A, pycnidia from culture on V-8 juice agar; B, section of same; C, chlamydospore-like cells; D, conidia from culture on V-8 juice agar; E, conidia from type.

Phyllosticta andropogonivora appears to be best classified in the genus *Ascochyta*, although its conidia are mostly unicellular, unlike those typical of the genus, which are one-septate (see Melnik, 1977; Punithalingam, 1979). In some of the isolates studied, a few septate conidia have been encountered. Sutton (1980) observed that there is considerable variation in conidial shape, septation, and size within the genus *Ascochyta*. A number of species, including *A. pisi* Lib., the type, form occasional conidia with two septa. Single septation is, therefore, not an absolute invariable characteristic in the genus, although that is the predominating condition of its conidia. *Phyllostica andropogonivora* is clearly a species that has to be excluded from *Phyllosticta* since it is not congeneric with *P. cruenta*. It is classified in *Ascochyta* herein and redescribed and illustrated.

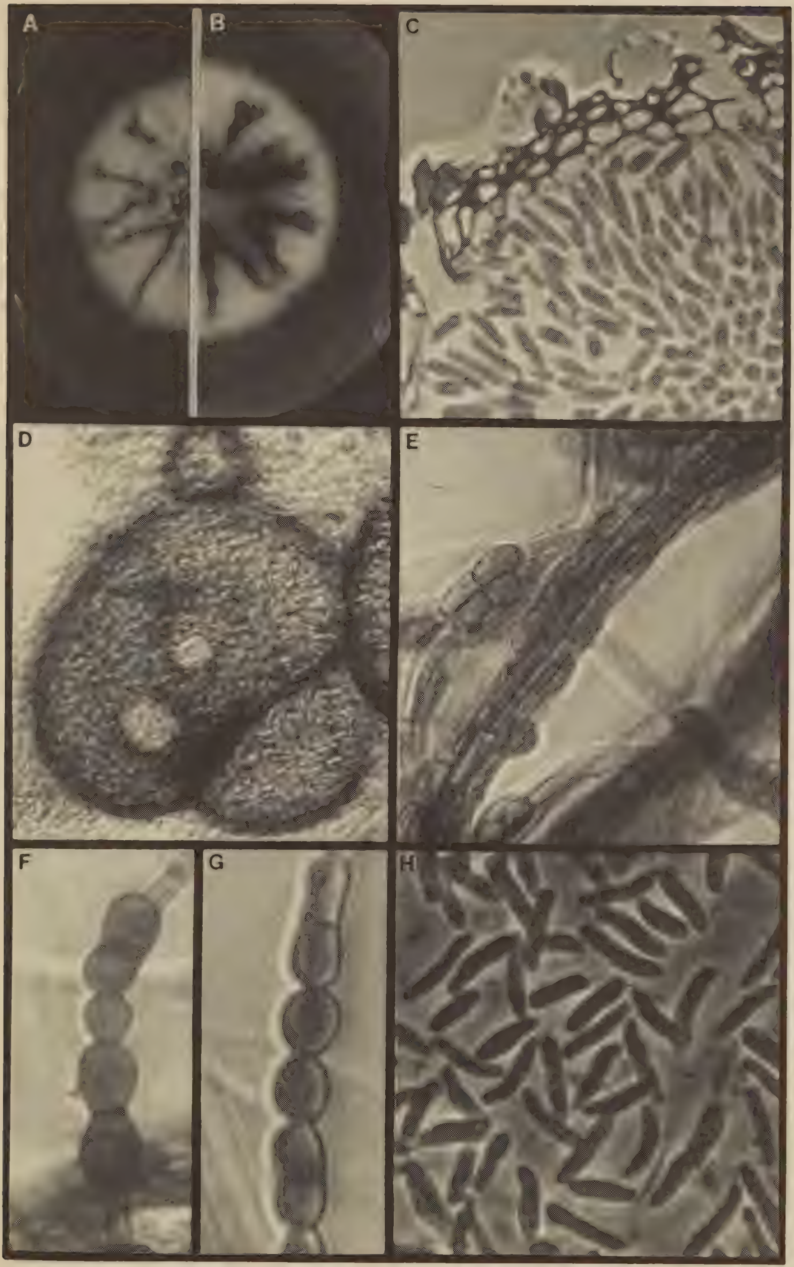
TAXONOMIC PART

Ascochyta andropogonivora (Sprague & Rogerson) Morgan-Jones, comb. nov. (Plate 1, Figure 1).

≡ *Phyllosticta andropogonivora* Sprague & Rogerson, *Mycologia* 50: 6, 1958.

Leaf spots suborbicular to sublinear, often extensive by confluence, reddish to purplish brown, often somewhat darker at the margin, amphigenous. Mycelium immersed in the substratum, composed of branched, smooth, thin-walled, hyaline to subhyaline, 2-3 µm wide hyphae. Pycnidia scattered, usually sparse, immersed, becoming partly erumpent when mature, dark brown to black, more or less subglobose, ostiolate, 70-140 µm in diameter. Ostiole 6-9 µm wide, bordered by slightly darker brown cells than the remainder of the pycnidial wall. Pycnidial wall pseudoparenchymatous, three to four cell layers thick. Outer pycnidial wall cells more or less isodiametric, thick-walled, pale to mid brown, 5-8 µm in diameter; those surrounding the ostiole smaller and tending to be somewhat elongate. Inner pycnidial wall cells thinner-walled, subhyaline. Colonies on potato dextrose agar [Difco] (Plate 1, A & B) grown at 25C somewhat variable among strains, the majority at first whitish, becoming pale salmony [7B3/7B4, Greyish Red to 6A3, Pale Orange] (Kornerup and Wanscher, 1978), usually more or less uniformly colored, sometimes with a slightly olivaceous tinge at the center [3E3, Olive], evenly and densely lanose, becoming somewhat felted and funiculose when older, with an even margin, attaining a diameter of 54-58 mm after 7 days, 79-84 mm after 14 days; reverse 6A4/7B4/7B5, Salmon to Greyish Red, in some strains with blackish, striate, irregular, fan-shaped sectors resulting from formation of dense masses of chlamydospore-like cells at and below the agar surface. Some strains with less evenly salmon-colored colonies, mottled, with cream [4A3, Pale Yellow] patches intermixed with Orange Grey or Greyish Orange [6B2/6B3] areas and an Olive Grey [3E2] center, slightly lobed and slower growing, attaining a diameter of 43-44 mm after 7 days, 75-79 after 14 days. Colonies on PDA grown at 20C and

PLATE 1. *Ascochyta andropogonivora*. A, 7-day-old colony on PDA grown at 25 C; B, reverse of same showing dark sectors resulting from formation of clusters of chlamydospore-like cells; C, section of pycnidial wall; D, bi-ostiolate pycnidium; E, hyphal rope; F & G, chlamydospore-like cells; H, conidia from 14-day-old culture on V-8 juice agar (phase contrast).


A
B
C
D
E
F
G
H

30C similar in general appearance and color to those grown at 25C but often having a minutely tufted to funiculous aspect at 30C, attaining a diameter of 47 to 59 mm at both temperatures after 7 days. Colonies on V-8 juice agar (Stevens, 1974) whitish at first, becoming Brownish Grey [6C2] and darker with age, producing abundant pycnidia, attaining a diameter of 57-58 mm after 7 days at 25C. In culture, hyphae of two kinds; thin-walled, hyaline to subhyaline, 2.5-3.5 µm wide, and thicker-walled, pale to mid brown, 4-5 µm wide, the latter often aggregated in strands (Plate 1, E) and giving rise to chlamydospore-like cells. Pycnidia produced *in vitro* (Plate 1, D) mostly superficial on the agar surface, variable in shape and size, solitary or, more frequently, gregarious in dense clusters, often confluent, more or less subglobose or irregularly shaped, brown to blackish, pseudoparenchymatous, unilocular, uniostiolate or sometimes multiostiolate or appearing so because of pycnidial confluence, non-papillate or very slightly papillate, of similar anatomy to those produced *in vivo*, up to 240 um in diameter. Ostioles circular, surrounded by darker-walled cells than the remainder of the pycnidial wall, up to 12 µm in diameter. Conidiogenous cells phialidic, hyaline, more or less doliiform, borne on inner cells of the pycnidial wall, 6.5-9 x 4.5-7 µm. Conidia enteroblastic, thin-walled, hyaline, smooth, cylindrical, obtuse at each end, straight or very slightly curved, aseptate, guttulate, 13.5-15 X 4-4.5 µm. Conidia in culture often somewhat curved, sometimes one-septate, guttulate, 14-19 X 3.5-4.5 µm. Chlamydospore-like, swollen, subglobose to globose, thick-walled, smooth or roughened, pale to mid to dark brown cells, 12-19 µm in diameter, produced in abundance *in vitro*, particularly in some strains, as long, intercalary chains (Plate 1, F & G) or in botryose clusters.

On living leaves of *Andropogon gerardii* and *Schizachyrium scoparium*; North America.

Collections examined: on *A, gerardii*, Beagle, Miami Co., Kansas, U.S.A., June 10, 1957, C.T. Rogerson, WSP, holotype; various isolates from *A. gerardii* and *S. scoparium* [dried cultures, bearing pycnidia, of isolates from *S. scoparium* originating in Minnesota, North and South Dakota, preserved in AUA].

DISCUSSION

Phyllosticta andropogonivora is reclassified in *Ascochyta* mainly on the basis of the shape and size of its conidia. In other characteristics, particularly pycnidial structure, it is closely similar to some species of *Phoma* Sacc., including the type species of that genus, *P. herbarum* Westd. (see Morgan-Jones, 1988a). In having multiostiolate pycnidia it resembles *P. herbarum* and *P. multirostrata* (Mathur, Menon & Thirum.) Dorenbosch & Boerema (see Morgan-Jones, 1988b). It is also similar to some *Phoma* species, such as *P. americana* Morgan-Jones & White, *P. eupyrena* Sacc., and *P. pinodella* (L.K. Jones) Morgan-Jones & Burch, in forming chains of chlamydospore-like cells. Those of *A. andropogonivora* bear a close likeness to those of *P. eupyrena* (see Morgan-Jones and Burch, 1988a) and the two species also produce hyphal ropes or strands *in vitro*. A number of species of *Phoma*, such as *P. exigua* Desm., *P. medicaginis* Malbr. & Roum., and *P. pinodella*, produce one-septate as well as aseptate conidia (see Morgan-Jones and Burch, 1988c; Morgan-Jones and Burch, 1987; White and Morgan-Jones, 1987). There is thus a continuum between *Ascochyta* and *Phoma*, the only distinguishing criterion being conidium length.

As indicated in the above description, conidia of *A. andropogonivora* produced *in vitro* are generally longer and slightly narrower than those produced in nature. Some variation in conidium size, numbers of guttules, and the presence or absence of a more or less median transverse septum, has been encountered among the various isolates studied. The following data, based on conidia obtained from pycnidia produced on leaves inoculated in the greenhouse (50 per isolate), are illustrative of this.

From little bluestem: average size = 14 X 3.6 µm; 36 with one prominent guttule at each end, 6 with more than one, 8 with a combination of the two conditions; 2 with septum.

From little bluestem: average size = 15.7 X 4.1 µm; 33 with one prominent guttule at each end, 16 with more than one, 1 with a combination of the two conditions; 0 with septum.

From big bluestem: average size = 18.5 X 4 µm; 37 with one prominent guttule at each end, 2 with more than one, 11 with a combination of the two conditions; 3 with septum.

From sand bluestem: average size = 15.7 X 3.9 µm; 22 with one prominent guttule at each end, 23 with more than one, 5 with a combination of the two conditions; 2 with septum.

From sand bluestem: average size = 16.4 X 3.7 µm; 30 with one prominent guttle at each end, 2 with more than one, 18 with a combination of the two conditions; 3 with septum.

Punithalingam (1979) monographed the species of *Ascochyta* occurring on members of the Gramineae and recognized seventy nine valid taxa from among over one hundred and fifty named species studied, some of which were previously classified in other genera, but none in *Phyllosticta*. No *Ascochyta* species were reported on *Andropogon gerardii*, but *Ascochyta poagena* Punith. was recorded from *Schizachyrium scoparium* as well as its type host *Poa glauca* Vahl and several other grasses. The collection cited on *S. scoparium* was originally identified as *Ascochyta brachypodii* (Syd.) Sprague and Johnston (Sprague and Johnston, 1950). *Ascochyta andropogonivora* is distinguishable from *A. poagena* and all other species occurring on grasses by the morphology of its conidia. Interestingly, in terms of shape, size and guttulation, conidia of *A. andropogonivora* are closely similar to those of the *Ascochyta* state of *Didymella exitialis* (Moroni) Müller. Apart from the fact that conidia of *A. andropogonivora* are rarely septate and are more obtuse at each end *in vivo*, there appears to be little difference between them. *Didymella exitialis* occurs on *Hordeum vulgare* L., barley, and *Triticum aestivum* L., wheat. Müller (1952) considered *Ascochyta sorghi* Sacc. to be the anamorph of *D. exitialis* and *A. elymi* Tehon & Daniels and *A. graminicola* Sacc. to be synonyms of it. Punithalingam (1979), however, has determined *A. sorghi* to be a different fungus with longer and appreciably wider conidia than the *Ascochyta* state of *D. exitialis*, *A. elymi* to be a synonym of *A. leptospora* (Trail) Hara, and *A. graminicola* to be *Darluca filum* (Biv.-Bern.) Cast., the anamorph of *Eudarluca caricis* (Fr.) O. Erikkss.

The *Ascochyta* state of *D. exitialis* was studied in culture by

Punithalingam (1979). From the description provided, a number of additional differences between it and *A. andropogonivora* are apparent. The colony characteristics on PDA differ. Pycnidia were reported to be produced sparsely on potato dextrose, potato sucrose, and oat agar and to be variable from subglobose to being aggregated into a stroma with several locules. No mention was made of ostioles. The pycnidial wall was said to be stromatic. Conidia formed in culture were found to be narrower than those produced on the host, an identical situation to that noted above in *A. andropogonivora*. In view of the occurrence of *Didymella* teleomorph pseudothecia, together with *A. andropogonivora* pycnidia, on the same leaf spot in the type material of the latter, it seems possible that the two belong to the same life cycle.

Three other *Ascochyta* anamorphs of *Didymella* spp. and one of *Didymosphaeria loliina* Punith., are known to occur on grasses. These are, in addition to the *Ascochyta* state of *Didymella exitialis*, the *Ascochyta* anamorphs of *D. graminicola* Punith. and *D. phleina* Punith. & Kåre Årsvoll [= *Ascochyta phyllachoroides* Sacc. & Marlb. forma *melicae* Fautrey]. Punithalingam (loc. cit.) noted the occurrence and illustrated mycelial chlamydospore-like cells produced *in vitro* on oat agar by *D. loliina* that appear very similar to those of *A. andropogonivora*. It thus appears that the latter has affinity with *Didymella/Didymellina* anamorphs and it may well be the conidial state of a hitherto undescribed teleomorph belonging to the former genus. In the same publication, Punithalingam expressed the opinion, in relation to *Didymella autumnalis* and *D. exitialis*, two species considered identical by Muller (loc. cit.), that although ascospore dimensions may be similar, if two species have differing *Ascochyta* anamorphs they need not necessarily be considered as one species.

Sivanesan (1984) documented thirteen species of *Didymella* Sacc. to have *Ascochyta* anamorphs. These include *D. lycopersici* Klebhan, whose anamorph, *Ascochyta lycopersici* (Plowright) Brunaud, is sometimes classified in *Phoma* as *P. lycopersici* Cooke [= *P. lycopersici* (Plowright) Jaczewski, a later synonym (see Sutton, 1980; Morgan-Jones and Burch, 1988b)].

ACKNOWLEDGMENTS

We thank Dr. Jack D. Rogers, Washington State University, Pullman, for the loan of the type specimen of *Phyllosticta andropogonivora* housed in Herb. WSP. Dr. Dean A. Glawe, Department of Plant Pathology, University of Illinois, Urbana, reviewed the manuscript.

LITERATURE CITED

DONK, M.A. 1968. Report of the committee for fungi and lichens 1964-1968. *Taxon* 17: 578-581.

KORNERUP, A. and J.H. WANSCHER. 1978. Methuen Handbook of Colour. 3rd Ed. Hastings House, New York, 252 pp.

KRUPINSKY, J.M., and D.A. TOBER. 1990. Leaf spot disease of little bluestem, big bluestem, and sand bluestem caused by *Phyllosticta andropogonivora*. *Plant Disease* 74: 442-445.

MELNIK, V.A. 1977. Opred-elitel' gribov roda *Ascochyta* Lib. Leningrad, 246 pp.

MORGAN-JONES, G. 1988a. Studies in the genus *Phoma*. XIV. Concerning *Phoma herbarum*, the type species, a widespread saprophyte. *Mycotaxon* 33: 81-90.

MORGAN-JONES, G. 1988b. Studies in the genus *Phoma*. XV. Concerning *Phoma multirostrata*, a leaf spot-inducing and soil-borne species in warm climates. *Mycotaxon* 33: 339-351.

MORGAN-JONES, G., and K.B. BURCH. 1987. Studies in the genus *Phoma*. VIII. Concerning *Phoma medicaginis* var. *medicaginis*. *Mycotaxon* 29: 477-487.

MORGAN-JONES, G., and K.B. BURCH. 1988a. Studies in the genus *Phoma*. X. Concerning *Phoma eupyrena*, an ubiquitous, soil-borne species. *Mycotaxon* 31: 427-434.

MORGAN-JONES, G., and K.B. BURCH. 1988b. Studies in the genus *Phoma*. XI. Concerning *Phoma lycopersici*, the anamorph of *Didymella lycopersici*, causal organism of stem canker and fruit rot of tomato. *Mycotaxon* 32: 133-142.

MORGAN-JONES, G., and K.B. BURCH. 1988c. Studies in the genus *Phoma*. XIII. Concerning *Phoma exigua* var. *exigua*, a cosmopolitan ubiquitous fungus on diseased and dead plant material. *Mycotaxon* 32: 477-490.

MÜLLER, E. 1952. Pilzliche erreger der getreidablattdurre. *Phytopath. Z.* 19: 402-416.

PETRAK, F., and H. SYDOW. 1927. Die Gattungen der Pyrenomyzeten, Sphaeropsideen und Melanconieen. *Beih. Repert. spec. nov. regni veg.* 42: 1-551.

PUNITHALINGAM, E. 1974. Studies on Sphaeropsidales in culture. II. *Mycol. Pap.* 136: 1-63.

PUNITHALINGAM, E. 1979. Graminicolous *Ascochyta* species. *Mycol. Pap.* 142: 1-214.

SIVANESAN, A. 1984. The Bitunicate Ascomycetes and their anamorphs. J. Cramer, Vaduz, 701 pp.

SPRAGUE, R. 1948. Some leaf spot fungi on western Gramineae. II. *Mycologia* 40: 177-193.

SPRAGUE, R. 1950. Diseases of Cereals and Grasses in North America. Ronald Press, New York, 538 pp.

SPRAGUE, R. 1962. Some leaf spot fungi on western Gramineae. XV. *Mycologia* 54: 44-61.

SPRAGUE, R., and A. G. JOHNSON. 1950. *Aschochyta* leaf spots of cereals and grasses in the United States. *Mycologia* 42: 523-553.

SPRAGUE, R., and C.T. ROGERSON. 1958. Some leafspot fungi on Kansas Gramineae. *Mycologia* 50: 634-641.

STEVENS, R. B. ed. 1974. Mycology Guidebook. University of Washington Press, 703 pp.

SUTTON, B. C. 1980. The Coelomycetes. Commonwealth Mycological Institute, 696 pp.

VAN DER AA, H.A. 1973. Studies in *Phyllosticta*. I. *Stud. Mycol.* 5: 1-10.

WHITE, JR., J.F., and G. MORGAN-JONES. 1987. Studies in the genus *Phoma*. VI. Concering *Phoma medicaginis* var. *pinodella*. *Mycotaxon* 28: 241-248.

MYCOTAXON

Volume XLII, pp. 63-75 October-December 1991

FUNGI OF YUCCA BACCATA 1. PIPTARTHRON PLURILOCULARE AND ITS TELEOMORPH, PLANISTROMA YUCCIGENA

ANNETTE RAMALEY

7 Animas Place
Durango, Colorado 81301

Introduction: In their detailed account of the genus *Kellermania* Ellis and Everhart, Morgan-Jones, Nag Raj, and Kendrick (4) redescribed the two existing species, *K. yuccaegena* Ellis and Everhart and *K. anomala* (Cooke) Höhnel. They also established two new species, *K. attenuata* and *K. multiseptata*, which had multilocular conidiomata and lacked an apical appendage on the conidia. The generic description was emended to accommodate the new species. Sutton (9) pointed out that *K. multiseptata* Morgan-Jones, Nag Raj, and Kendrick, was a later name for *Piptarthron macrosporum* (Durieu & Montagne) Höhnel, the type of *Piptarthron*. Sutton also placed *K. attenuata* Morgan-Jones, Nag Raj, and Kendrick into synonymy with *Piptarthron limbatum*, since he had concluded (8) *Septoplaca limbata* Petrak was undoubtedly a *Piptarthron* and provided an earlier name for *K. attenuata*. An earlier name for *P. limbatum* (Petrak) Sutton was provided by the new combination *Piptarthron yuccae* (Ellis & Everhart) Sutton (10). A third species of the this interesting genus was discovered on leaves of *Yucca baccata* Torrey in southwestern Colorado, U.S.A. Most of the sporulating stromata occurred on dead leaves. In rare instances, stromata occurred on dead spots on living leaves, but they were usually accompanied by *Botryosphaeria sp.* or *Coniothyrium bartholomaei* Dearness and Bartholomew. Both these fungi are common parasites of *Y. baccata* in southwestern Colorado.

Piptarthron pluriloculare sp. nov., Fig. 1.

Stromata amphigena, subepidermalia, atra, immersa, partim erumpentia per divisuram accuratam et exuturam epidermidis prope peripheriam stromatum etiam obtecta in margine per epidermidem, separata vel confluentia, hemisphaerica in sectione, pars complanata pagina folii, glabra, 400-1000 μm diam ubi separata, ubi confluentia stromata linearia usque ad 4 mm longa

formantia, usque ad 550 µm elata, plurilocularia, 4-30 vel plus loculi in stromatibus simplicibus. Paries cupulatus, affixus in epidermide hospitis, 70-100 µm crassus in base, 65-90 µm crassus in lateribus, ex textura angulari atrobrunnea crassipariete compositus, coloratus pallidius versus partem interiorem, 10-15 vel plus cellulis crassis. Stratum supremum stromatum ex columnis cellularum elongatarum compositum, columnae extensae ex base et lateribus parietis cupulati ad superficiem stromatum, dividentes stromata in loculos. Ostiolum unum in quoque loculo, 8-15 µm latum, expositum per disrumpentem epidermidems hospitem in margine interiore parietis cupulati. Conidiophora absentia. Cellulae macroconidiogenae in parietibus lateralibus et basalibus loculorum formatae, brevescylindratae, hyalinae, leves, 6.5-14.5 x 3.5-5.5 µm, omnes conidium unum acrogenum, holoblasticum formantes. Macroconidia fusiformia, saepe curvata vel flexa, angustata versus apices et minus angustata versus bases, bases plerumque truncatae, plerumque aseptata, levia, hyalina, (48-)59-76(-98) x (4-)5.5-7(-8) ($\bar{x}$=67.8 x 6.5) µm. Cellulae microconidiogenae in parietibus superioribus loculorum formatae, parviores quam cellulae macroconidiogenae, microconidia acrogena formantes. Microconidia cylindrata, tumescentia irregularia vel flexa, aseptata, levia, hyalina, 5.5-25 x 2.5-3.5 µm. Spermatia in parte parietum lateralorum vel basium loculum macroconidiogenum vel in uno vel plus loculis separatis formata in stromate. Cellulae spermatogenae in parietibus basalibus et lateralibus loculorum formatae, phialidicae, cylindratae ad elongatas-conicas, ca 8-16 x 1.5-3 µm, discretae vel integratae in conidiophoro unicellulario, determinatae, hyalinae, leves, tenui-parietes, spermatia acrogena formantia. Spermatia bacilliformia, hyalina, aseptata, levia, tenui-parietes, 3.5-5.5 x 1.5 µm. Cellulae conidiogenae in parietibus superioribus loculorum spermatogenorum plerumque macroconidia formantes atque in loculis macroconidiogenis.

Holotypus: in foliis emortuis *Yucca baccata,* Fort Lewis College, Durango, Colorado, U.S.A., 28-IV-90, UC 1475060.

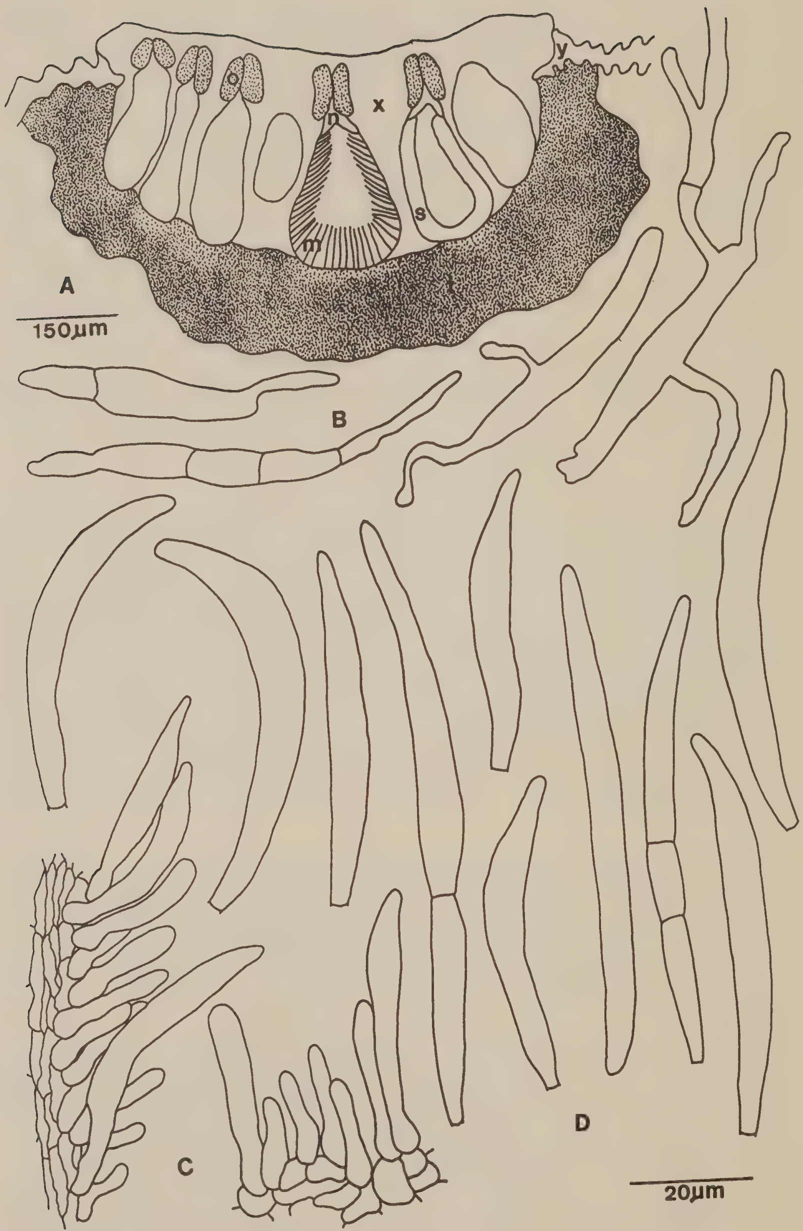
Stromata (Fig. 1, A) amphigenous, subepidermal, black, immersed, erumpent by a precise parting and lifting off of the epidermis near the periphery of the stromata but a rim remaining covered by the epidermis, separate or confluent, hemispherical in section, the flattened portion at the leaf surface, glabrous, 400-1000 µm diam when separate, forming linear stromata up to 4 mm long when confluent, up to 550 µm thick, multilocular, 4-30 or more locules in simple stromata. Wall (Fig. 1, E, F) cup-shaped, attached to the host epidermis, 70-100 µm thick at the base, 65-90 µm thick at sides, composed of dark brown, thick-walled textura angularis, lighter colored toward the interior, 10-15 or more cells thick. The top layer (Fig. 1, E) of the stromata composed of columns of elongated cells, the columns extending from the base and sides of the cup-shaped wall to the top surface of the stromata, subdividing the stromata into locules. One ostiole per locule, 8-15 µm wide, exposed by breaking away of the host epidermis at the inner edge of the cup-shaped wall. Conidiophores absent. Macroconidiogenous cells (Fig.

1, C) formed on lateral and basal walls of the locules, short cylindric, hyaline, smooth, 6.5-14.5 x 3.5-5.5 μm, each forming a single, acrogenous, holoblastic conidium. Macroconidia (Fig. 1, D) fusiform, often curved or bent, tapering toward the apex and less so toward the base, base generally truncate, mostly aseptate, smooth, hyaline, (48-)59-76(-98) x (4-)5.5-7(-8) ($\bar{x}$=67.8 x 6.5) μm. Microconidiogenous cells formed on the upper walls of the locules (Fig. 1, A), smaller than the macroconidiogenous cells, forming acrogenous microconidia. Microconidia (Fig. 1, G) cylindric, irregularly swelled or bent, aseptate, smooth-walled, hyaline, 5.5-25 x 2.5-3.5 μm. Spermatia formed on a part of the lateral or basal walls of a macroconidiogenous locule or in one or more separate locules (Fig. 1, A) in a stroma. Spermatogenous cells (Fig. 1, H) formed on the basal and lateral locular walls, phialidic, cylindric to elongate-conical, ca 8-16 x 1.5-3 μm, discrete or integrated on a one-celled conidiophore, determinate, hyaline, smooth, thin-walled, forming acrogenous spermatia. Spermatia (Fig. 1, J) bacillary, hyaline, aseptate, smooth, thin-walled, 3.5-5.5 x 1.5 μm. Conidiogenous cells on the upper walls of spermatogenous locules generally forming microconidia as found in macroconidiogenous locules.

The upright columns of cells in young stromata are thin-walled and pale yellow-brown between the conidiogenous locules, black surrounding the ostioles, nearly hyaline for 1-3 cell layers at the surface, and pale to dark brown in a zone below the hyaline layer and above the belly of the locules. In older stromata the columns of cells become progressively and uniformly darker brown and thicker walled, and the hyaline surface cells may be obliterated. The separation of the stroma into (a) a cup of more or less thickwalled textura angularis, and (b) a body formed of columns of thin-walled cells originating from the cup, is not peculiar to *P. pluriloculare*. The same basic structure is found in *Piptarthron yuccae, Kellermania yuccaegena*, and two species of a new genus from *Yucca baccata* that will be described in a later publication.

The microconidia formed on the upper locular walls are 5.5-9 μm in length in material collected in the spring, whereas in fall collections they are up to 25 μm long. Microconidia are found on the upper locular walls of several fungi from *Yucca* besides *Piptarthron pluriloculare* including two species of a genus to be described later, and *Kellermania yuccaegena.* The function of these microconidia is unknown.

Table 1. summarizes differences in the conidia and conidiomata of the three species of *Piptarthron.* Conidia of *P. pluriloculare* are aseptate with rare exception, shorter, and broader than the aseptate conidia of *P. yuccae* (4) and longer than conidia of *P. macrosporum* (4) which are multiseptate. *P. pluriloculare* conidiomata are generally larger than those of the other two species and are multilocular rather than 2-4 locular as are *P. yuccae* conidiomata. There is also a striking difference in dehiscence. *P. yuccae* and *P. macrosporum* ostioles are erumpent, and most of the associated conidioma


o
x
y
n
s
m
A
150µm
B
C
D
20µm

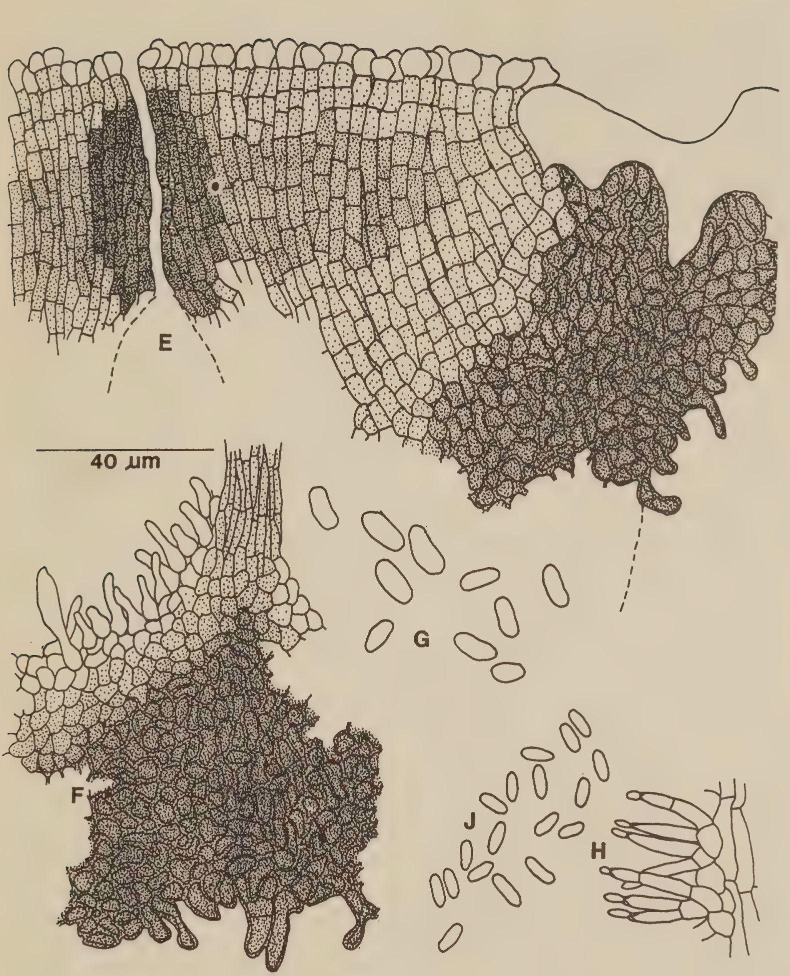


Figure 1. *Piptarthron pluriloculare.* A. diagram of a conidiomatal stroma (m=macroconidiogenous area, n=microconidiogenous area, o=blackened area surrounding ostiole, s=spermatogenous area, t=cup-shaped wall of textura angularis, x=columnar portion of stroma, y=host epidermis); B. germinating conidia after 24 hours on PDA; C. macroconidiogenous cells; D. macroconidia; E. detail of portion of a conidiomatal apex; F. detail of portion of a conidiomatal base in the vicinity of a locule; G. microconidia; H. spermatiogenesis; J. spermatia.

remains covered by the host epidermis (4). The conidiomatal surface of *P. pluriloculare* is entirely exposed by the precise lifting off of the overlying epidermis at the inner edge of the cup-shaped conidiomatal wall.

TABLE 1. COMPARISON OF THREE PIPTARTHRON SPECIES

	P. yuccae	*P. macrosporum*	*P. pluriloculare*
Conidium:			
Size(μm)	70-85x3-5	50-68x6-7.5	59-76x5.5-7
Septation	none	multiseptate	none (rarely 1)
Conidiomatal stroma:			
Size(mm)	.5-.6x.3-.35	.55-.6x.27-.3	.4-1x.3-.55
# locules	2-4	multilocular	multilocular
dehiscence	erumpent, ostiole	erumpent, ostiole	excission of epidermis over conidioma

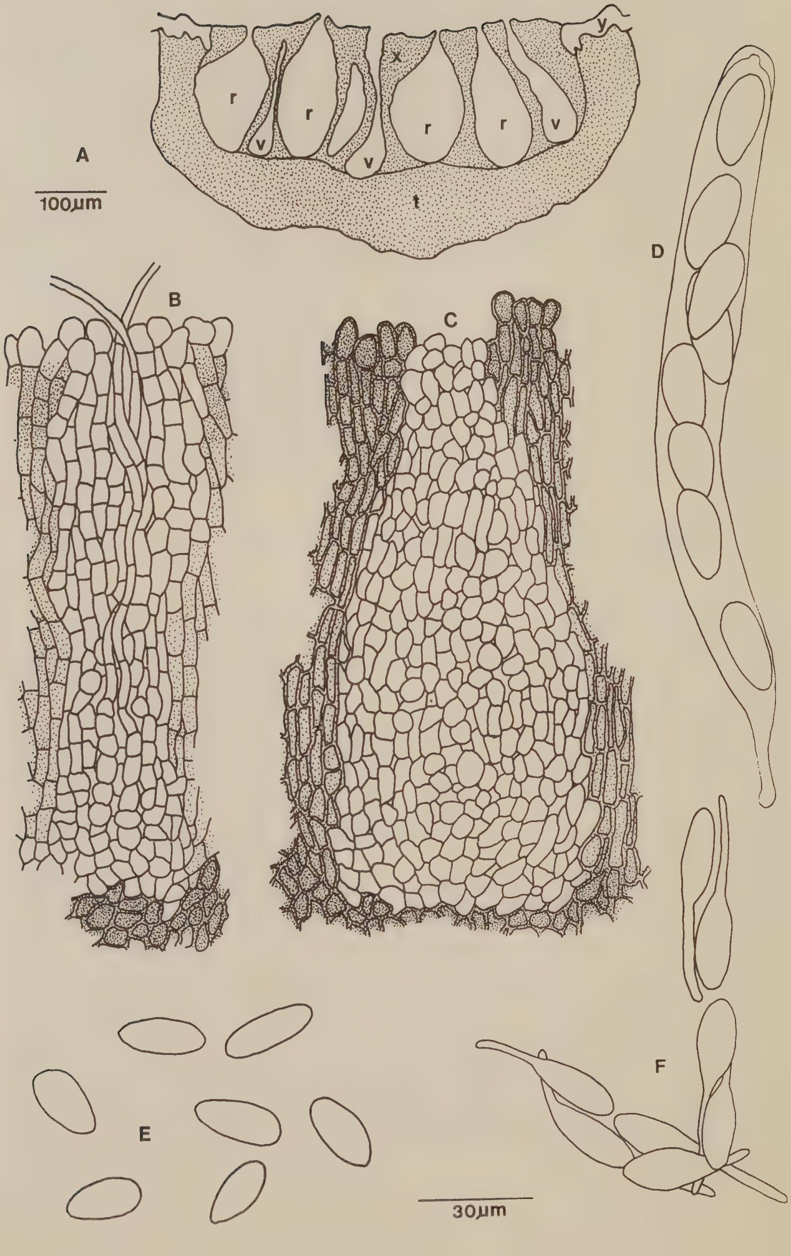
Introduction: *Dothidea conspicua* Griffiths was reported to be the teleomorph for *Piptarthron yuccae* (1). This seemed questionable since *Systremmopsis* Petrak is the coelomycetous conidial anamorph (3, 9), and *Asteromellopsis* Hess and Müller is cited as the spermogonial state for *Dothidea* (3, 9). Details are lacking, but as it is understood, spermatiogenesis and the structure of *Asteromellopsis* are significantly different from spermatiogenesis and the structure of *Piptarthron pluriloculare*. A *Dothidea* indistinguishable from *D. conspicua* is commonly found on *Y. baccata*, sometimes sharing the same leaves or spots with *P. pluriloculare*. *Yucca baccata* leaves with both *Dothidea* sp. and *P. pluriloculare* were collected from the type locality for *P. pluriloculare* to try to determine whether these fungi were phases in the same life cycle. Work with *Dothidea* was discontinued when a new fungus was found with stromata having one to many locules containing asci, as well as empty locules deformed by development of the ascogenous locules. The stromata were structurally identical to those of *Piptarthron pluriloculare*, but were generally darker and more uniformly thick-walled at the time ascospores were being released.

Planistroma yuccigena gen. et sp. nov., Fig. 2.

Stromata amphigena, subepidermalia, atra, immersa, partim erumpentia per divisuram accuratam et exuturam epidermidis prope peripheriam stromatum etiam obtecta in margine per epidermidem, separata vel confluentia, hemisphaerica in sectione, pars complanata pagina folii, glabra, 400-1000 μm diam ubi separata, usque ad 550 μm elata, plurilocularia. Paries cupulatus, affixus in epidermide hospitis, 70-100 μm crassus in base, 65-90 μm crassus in lateribus, ex textura angulari atrobrunnea, crassipariete compositus, 10-15 vel plus cellulis crassis. Stratum supremum stromatum ex columnis cellularum compositum, columnae extensae ex base et lateribus parietis cupulati ad superficiem, dividentes stromata in loculos. Unus ad multos loculos ascogenos exorientes in isdem stromatibus ac loculi conidiogeni et/vel spermatogeni, maturescentes post conidia et/vel spermatia. Loculi ovoidei, unistrati, separati per columnas ex cellulis brunneis, elongatis, aliquantum crassisparietibus compositis, saepe collabentes parietes loculorum conidiogenorum cassorum, paries perithecii non distinguibilis. Asci bitunicati, cylindrati, octospori, ca 200 x 18-20 μm, stipes 16-25 μm. Ascosporae ovoideae, extremum parvius versus basem asci deorsum, aseptatae, hyalinae, interdum circumcinctae strato muci usque ad ca 3 μm, 18.5-28 x 8.5-12 μm sine muco. Paraphyses et pseudoparaphyses abesntes; periphyses praesentes.

Holotypus: in foliis emortuis *Yucca baccata*, Fort Lewis College, Durango, Colorado, U.S.A., 26-IX-90, UC 1475061.

Stromata amphigenous, subepidermal, black, immersed, partially erumpent by a precise parting and lifting off of the epidermis near the periphery of the stromata but a rim remaining covered by the epidermis, separate or confluent, hemispherical in section, the flattened portion at the surface of the leaf, glabrous, 400-1000 μm diam when separate, up to 550 μm thick, multilocular. Wall cup-shaped, attached to the host epidermis, 70-100 μm thick at the base, 65-90 μm thick at the sides, composed of dark brown, thick-walled textura angularis 10-15 or more cells thick. The top layer of the stromata composed of columns of cells, the columns continuous from the base and sides of the cup-shaped wall to the top surface, subdividing the stromata into locules. One to many ascogenous locules developing in the same stromata as the conidiogenous and/or spermatogenous locules, reaching maturity after the conidia and/or spermatia. Locules ovoid, in a single layer, separated by columns of brown, rather thick-walled, elongated cells, often collapsing the walls of empty conidial locules (Fig. 2, A), no discernable perithecial wall. Asci (Fig. 2, D) bitunicate, cylindric, 8-spored, ca 200 x 18-20 μm, stipe 16-25 μm. Ascospores (Fig. 2, D, G) ovoid with the smaller end directed toward the ascus base, aseptate, hyaline, sometimes surrounded by a slime layer up to ca 3 μm wide, 18.5-28 x 8.5-12 μm without the slime layer. Paraphyses and pseudoparaphyses absent; periphyses present.


A
100µm
r
v
x
y
t
B
C
D
E
F
30µm

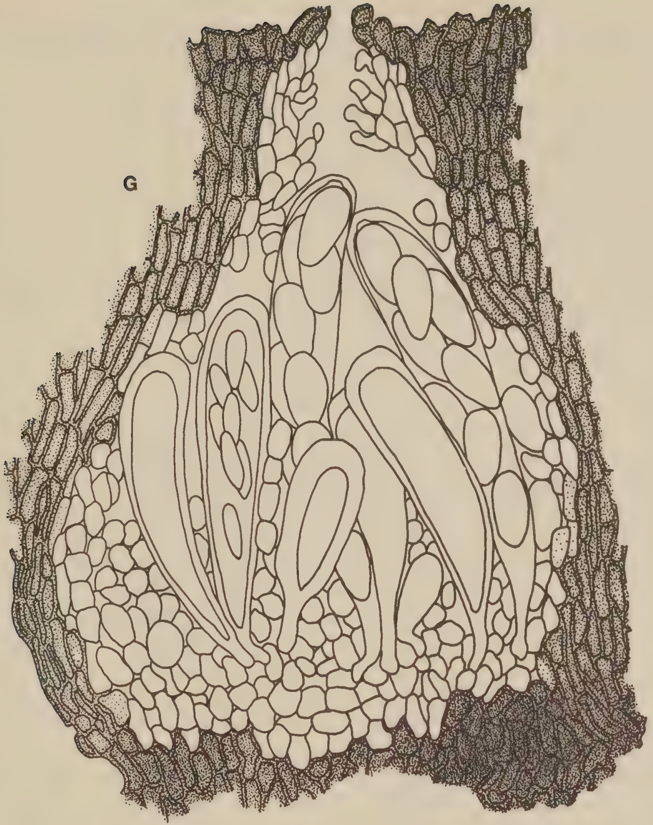


Figure 2. *Planistroma yuccigena.* A. semi-diagrammatic section of a stroma with mature ascogenous locules (r=ascogenous locule, t=cup-shaped wall of textura angularis, v=collapsed conidiogenous or spermatogenous locule, x=columnar portion of stroma with darkened, thick-walled cells, y=host epidermis); B. very young ascogenous locule with flexuous hyphae extending toward and above the stroma surface; C. older ascogenous locule before asci develop; D. mature ascus; E. ascospores; F. germinating ascospores; G. developing asci in a mature locule, periphyses present--note lack of wall that is differentiable from cells of the stroma.

The small bacillary cells formed in parts of conidiomatal locules, separate locules, or all the locules in a stroma are believed to be spermatia. They are the size and shape of cells shown to be spermatia in other genera. In addition, cells of this form and size adhere to clusters of hyphae extending beyond the top surface of the stromata. These hyphae can be traced through the columnar cells of a stroma to several short series of enlarged rounded cells (Fig. 2, B) at the base of very young developing ascogenous locules.

Ascus development takes place among the cells of the pseudoparenchyma in the locules (Fig. 2, G). The non-reproductive cells gradually disappear beginning at the upper portion of the locule belly and proceeding downward. Short series of these cells can sometimes be seen between asci, but they are not considered paraphyses because the cells involved do not differ significantly from the other cells of the pseudoparenchyma, and their presence is unpredictable. The numerous (>40) asci do not develop simultaneously, so that a locule often contains mature asci and those beginning development. When dry sections are moistened, asci nearing maturity expand greatly so that the tips overtop the stromatal surface ca 60 μm. The asci are thick-walled during early development, but the walls are thinned as ascus expansion proceeds. The contents of an ascogenous locule are not surrounded by a wall derived from spermatization (Fig. 2, G). Though layers of hyaline to brown, thin- to thick-walled cells can sometimes be seen at the periphery of the locule, these arise from the columnar stromatic cells. In favorable sections the 'wall' cells are seen to be continuous with columns of cells proceeding to the upper stromatic surface and separated from the locule. Also, since the conidiomatal locules are reduced and reshaped by developing ascomatal locules, the cells in the columnar region of stromata are pliable, even when more or less thick-walled, and are thus capable of being shaped to resemble a perithecial wall.

Table 2. compares *Planistroma* to some similar genera. Stromata of *Planistroma* are partially erumpent. The epidermis is shed from the barely protruding planar surface corresponding to the portion of the stroma made up of columns of elongate cells. The wall of the stroma remains below and in contact with the host epidermis. In contrast, stromata of *Dothidea* and *Bagnisiella* are erumpent and those of *Auerswaldiella* and *Coccodiella* appear to be superficial with a foot into the underlying host tissues. The ostioles of *Phyllachora* and *Glomerella* are exposed, but the remainder of the fungus does not break through the portion of the host under which it developed. Multilocular stromata whose cells are not separated from the aparaphysate ascogenous locular contents by a perithecial wall are characters common to *Planistroma,* and *Dothidea.* *Dothidea*, however, has septate, colored, ascospores in bitunicate asci. Like *Planistroma*, *Bagnisiella* is aparaphysate and has hyaline, aseptate ascospores in a bitunicate ascus, but the asci develop in what is often a nearly continuous layer on top of the stroma instead of in distinctly separate locules. *Planistroma* characteristics that suggest *Phyllachora* or *Glomerella* are (a) multilocular stromata in which conidium production precedes ascospore formation, and, (b) hyaline, aseptate ascospores. However, both latter genera have paraphyses, unitunicate asci, and the ascogenous contents are separated from the stroma by a wall in *Phyllachora*, and may be so separated in *Glomerella.* In addition, the 'stroma' of *Phyllachora* usually is formed by the confluence of perithecial

TABLE 2. COMPARISON OF SOME PYRENOMYCETES WITH PERITHECIA OR ASCOGENOUS LOCULES IN A STROMA.

Genus	Position	Dehiscence	Differentiable Perithecial Wall	Ascus Type	Ascospore Color/Septation	Paraphyses
Auerswaldiella	'superficial' with foot	ostiole	yes	bitunicate	hyaline--brown/ aseptate	pseudoparaphyses
Bagnisiella	erumpent from bark	rupture of stroma	no	bitunicate	hyaline/aseptate	no
Dothidea	subepidermal erumpent	ostiole, stroma breaks epidermis	no	bitunicate	colored/septate	no
Planistroma	subepidermal semi-erumpent	ostiole, epidermis removed	no	bitunicate	hyaline/aseptate	no
Coccodiella	'superficial' with foot	ostiole, stroma overtops host tissue	yes	bitunicate	hyaline--brown/ aseptate	yes
Glomerella	epi- subepidermal	erumpent ostiole	sometimes	unitunicate	hyaline/aseptate	yes
Phyllachora	subcuticular-epi- subepidermal innate	erumpent ostiole	yes	unitunicate	hyaline/aseptate	yes

walls and it expands laterally so that perithecia in the center are more mature than those at the periphery (5), and, at least in graminicolous species, with few exceptions (6,7) the various conidia (not spermatia) attributed to *Phyllachora* spp. are hyperparasites. Among the genera in Table 2, *Bagnisiella* seems to most closely resemble *Planistroma.* The base of a *Bagnisiella* stroma may contain old coelomycetous locules with hyaline, 1-celled conidia. The asci are separated by more or less numerous columns of cells. However, in *Bagnisiella* the asci are distributed in a broad, flat layer, often in a single locule, the stromata are erumpent from branches of woody plants, and the ascospores are released through rupture of the stroma, not through an ostiole. In addition, the interthecial strands of *Planistroma* are derived from processes associated with ascus formation while in *Bagnisiella*, the strands separating the asci appear to be a part of the vegetative stroma and are thus comparable to the columns of cells separating the locules of *Planistroma.*

The connection of Planistroma yuccigena to Piptarthron pluriloculare.

Conidia from fresh tendrils on *Piptarthron pluriloculare* stromata were collected with a sterile needle and suspended in a drop of sterile tap water on commercial potato dextrose agar (PDA). The drop was spread over the agar surface. Within twenty-four hours, the conidia had germinated (Fig. 1, B). At least one major hypha was aerial. Some conidia became septate during germination, while others remained undivided. The aerial and subsurface mycelia were white, but mycelium at and below the surface blackened with age. The aerial mycelium gradually diminished but remained white. No stromata or conidia were formed.

Asci from *Planistroma yuccigena* were washed twice in sterile tap water and placed on PDA. Germ tubes from the ascospores could be seen within two hours (Fig. 2, F). Within twenty-four hours both subsurface and aerial mycelium were present. Colonies from the asci could not be distinguished from those from *Piptarthron pluriloculare* conidia. These results confirm that *Planistroma yuccigena* and *Piptarthron pluriloculare* are part of the same fungal life cycle. This does not prove a lack of connection for *Dothidea conspicua* and *Piptarthron yuccae*, but does suggest that it is unlikely. The cultural conidial form for *Dothidea* is *Aureobasidium*-like (2), or *Cladosporium* (3), not a sterile mycelial form as was obtained from *Piptarthron pluriloculare* conidia. In addition, the intimate association of teleomorph and anamorph in the same stroma for *P. pluriloculare* raises doubts that *P. yuccae* would have so distinctive a teleomorph as *Dothidea* in separate stromata. When appropriate material is examined, the teleomorph for P. yuccae will probably more closely resemble *Planistroma* than *Dothidea.*

Since the perfect and imperfect stages of *Planistroma* are found in the same stromata in similar locules, *Phyllachora yuccae* Ellis and Everhart, a synonym of *Piptarthron yuccae* (10), was suspected of having been the first described species of *Planistroma*. The genera have several distinguishing features, but, before these characteristics were recognized *Planistroma* might have been called a *Phyllachora*. However, no '*Phyllachora*' was found on the type, the conidia having been described as asci (M. E. Barr Bigelow, personal communication).

Acknowledgements: My special thanks fo Margaret Barr Bigelow for reviewing the manuscript. Her patience, helpful comments, and suggestions as I worked with the teleomorph are much appreciated. I also thank the National Fungus Collections (BPI) for the loan of their specimens of *Bagnisiella australis* Speg. on *Morus alba* and *Prosopis* for my study, and Edouard Thai for his help with the Latin descriptions.

Literature Cited

1. Farr, D. F., Bills, G. F., Chamuris, G. P., and Rossman, A. Y. 1989. Fungi on plants and plant products in the United States. American Phytopathological Society, 3340 Pilot Knob Road, St. Paul, Minnesota 55121, U. S. A.
2. Hermanides-Nijhof, E. J. 1977. *Aureobasidium* and allied genera. Stud. Mycol. 15: 141-177.
3. Loeffler, W. 1957. Üntersuchungen über die Ascomycetengattung *Dothidea* Fr. Phytopath. Z. 30: 349-386.
4. Morgan-Jones, G., Nag Raj, T. R., and Kendrick, B. 1972. Genera coelomycetarum. VI. *Kellermania*. Can. J. Bot. 50: 1641-1648.
5. Orton, C. R. 1924. Studies in the morphology of the ascomycetes I. The stroma and the compound fructification of the Dothideaceae and other groups. Mycologia 16: 49-95.
6. Parbury, D. G. 1967. Studies on graminicolous species of *Phyllachora* Nke. in Fckl. Aust. J. Bot. 15: 271-375.
7. Parbury, D. G. 1971. Studies on graminicolous species of *Phyllachora* Nke. in Fckl. Aust. J. Bot. 19: 207-235.
8. Sutton, B. C. 1977. Coelomycetes VI. Nomenclature of generic names proposed for Coelomycetes. Mycol. Pap. 141: 1-253.
9. Sutton, B. C. 1980. The Coelomycetes. Commonwealth Mycol. Inst., Kew, Surrey, England.
10. Sutton, B. C. 1983. Nomenclatural notes on deuteromycetes. Trans. Br. mycol. Soc. 81: 407.

MYCOTAXON

Volume XLII, pp. 77-87 October-December 1991

"Lecanora" opiniconensis: a placodioid member of the Parmeliaceae (lichenized Ascomycotina)

H.Thorsten LUMBSCH, Kerstin E. SCHMITZ, G. Benno FEIGE

Botanisches Institut, Universität Essen, Fachbereich 9, Postfach 103 764,
D-4300 Essen 1, Germany

Summary

The ascoma development of *Lecanora opiniconensis* BRODO is studied. The ontogeny follows the pattern described for the Parmeliaceae with the production of a cupular excipulum. For comparision the apothecial anatomy of *Omphalodium pisacomense* MEYEN & FLOT., *Omphalora arizonica* (TUCK. ex WILL.) NASH & HAFELLNER, *Pleurosticta acetabulum* (NECK.) ELIX & LUMBSCH, *Rhizoplaca chrysoleuca* (SM.) ZOPF, *Rhizoplaca melanophthalma* (RAM.) LEUCKERT & POELT which also belong to the Parmeliaceae, and *Lecanora polytropa* (HOFFM.) SCHAERER, a typical member of the Lecanoraceae, are examined. *"L." opiniconensis* probably represents a separate genus within the Parmeliaceae.

Introduction

While in early systems of lichenized fungi (e.g. NYLANDER 1858 - 1869) stressed the importance of the growth form of lichens, it was ZAHLBRUCKNER (1926) who emphasized the use of apothecial and spore characteristics for the delimination of higher categories. ZAHLBRUCKNER and other authors thought that there was a strong relationship between the mainly crustose Lecanoraceae, the foliose Parmeliaceae and fruticose lichens which were separated in early systems as Usneaceae.

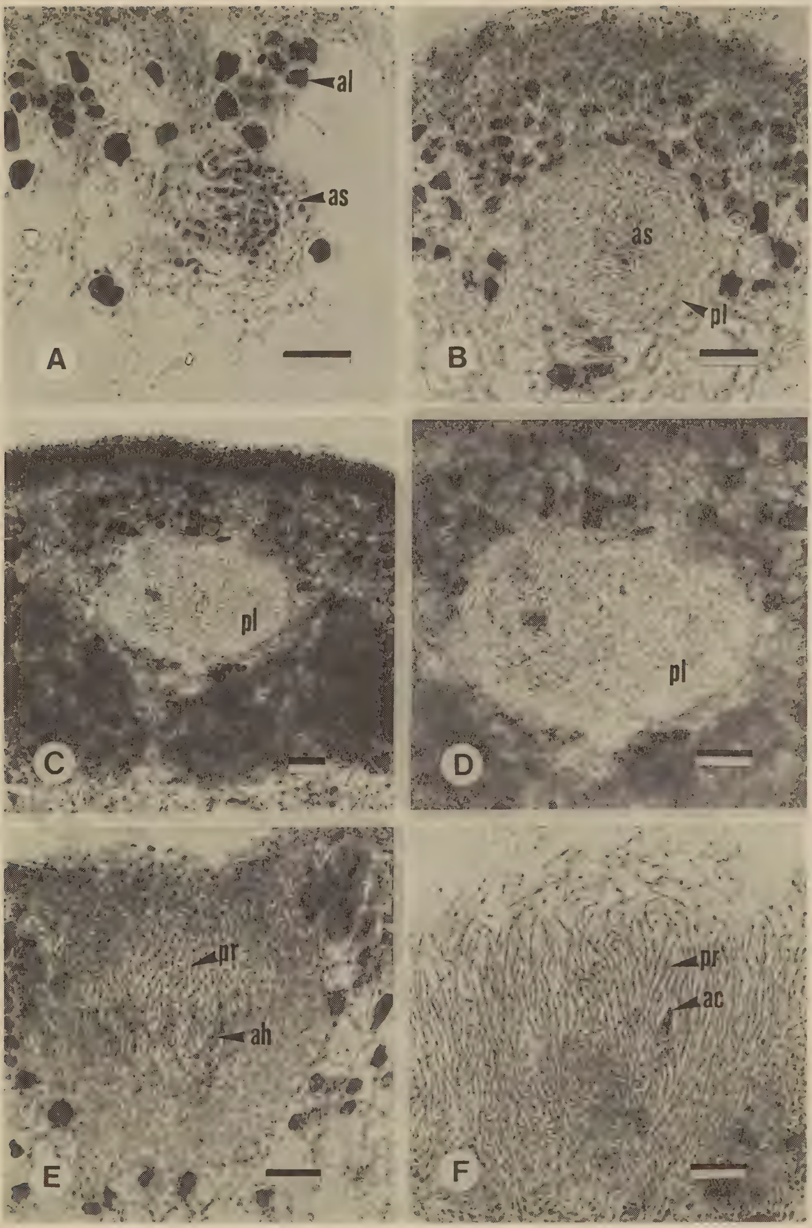
For example HILLMANN (1936) wrote the following about the systematic position of the Parmeliaceae: "Was die systematische Stellung der Familie betrifft, so schließt sie sich nach unten gut an die Lecanoraceen, besonders deren Sect. *Placodium* an; nach oben bilden die Usneaceen ... die phylogenetische Fortsetzung." However, the ontogenetic studies of the French school (LETROUIT-GALINOU & LALLEMANT 1970) and HENSSEN and coworkers (HENSSEN & JAHNS 1973, HENSSEN et al. 1981) clearly showed that the Parmeliaceae are characterized by their special development of the ascomata. A meristematic cupular excipulum and a strongly gelatinized layer in a zeorine apothecium are formed. Since the Usneaceae show the same development, HENSSEN & JAHNS (1973) included this group in the Parmeliaceae. However, the Lecanoraceae were shown to differ significantly in their ascoma-ontogeny and possess lecanorine apothecia. HAFELLNER (1984) questioned the distinction between some members of the Parmeliaceae and the Lecanoraceae. These doubts may be justified given the ill-defined nature of several taxa included within the still heterogenous family Lecanoraceae.

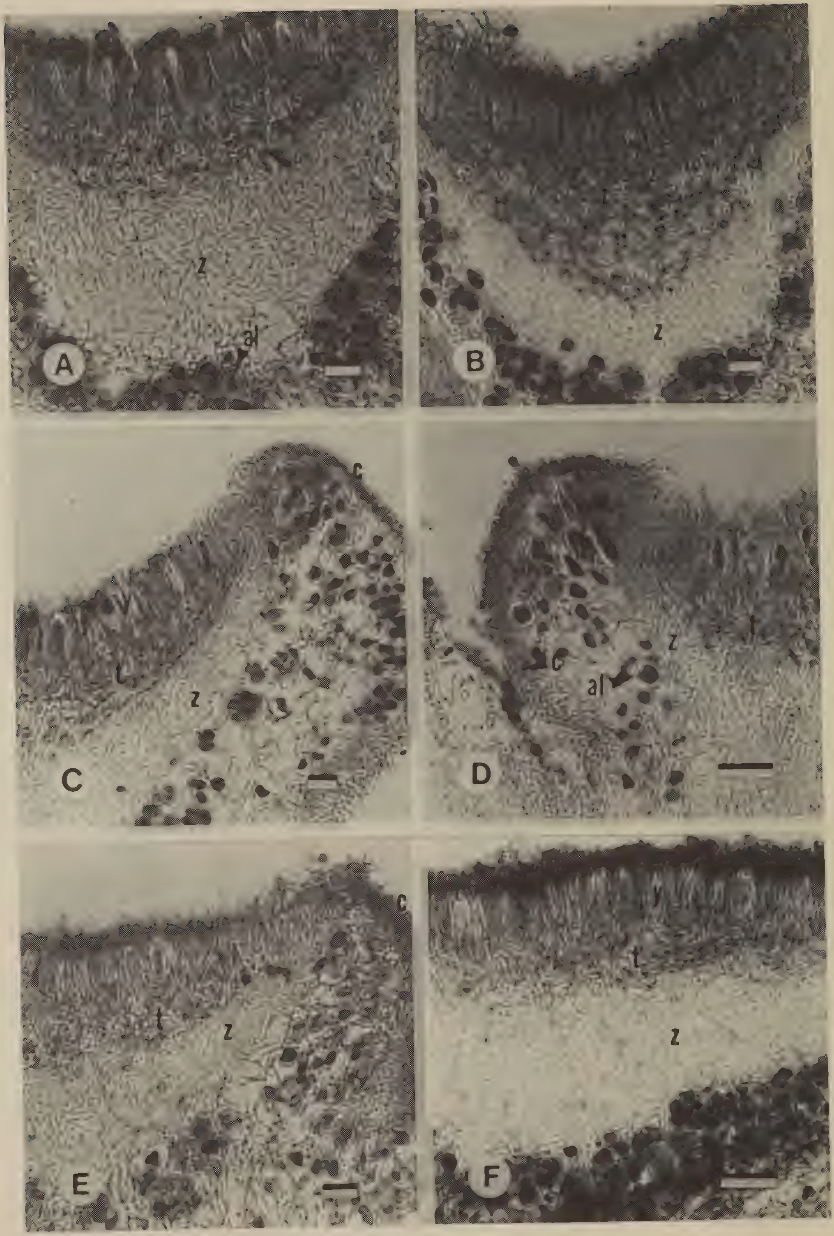
We have examined a number of genera containing usnic acid as the major cortical substance and forming a more or less umbilicate thallus, which were listed as members of the Lecanoraceae or Parmeliaceae by ERIKSSON & HAWKSWORTH (1987). Among these taxa the genera *Omphalodium*, *Omphalora* and *Rhizoplaca* showed a parmelioid anatomy of the ascomata. Subsequently we studied the anatomy and development of the fruiting

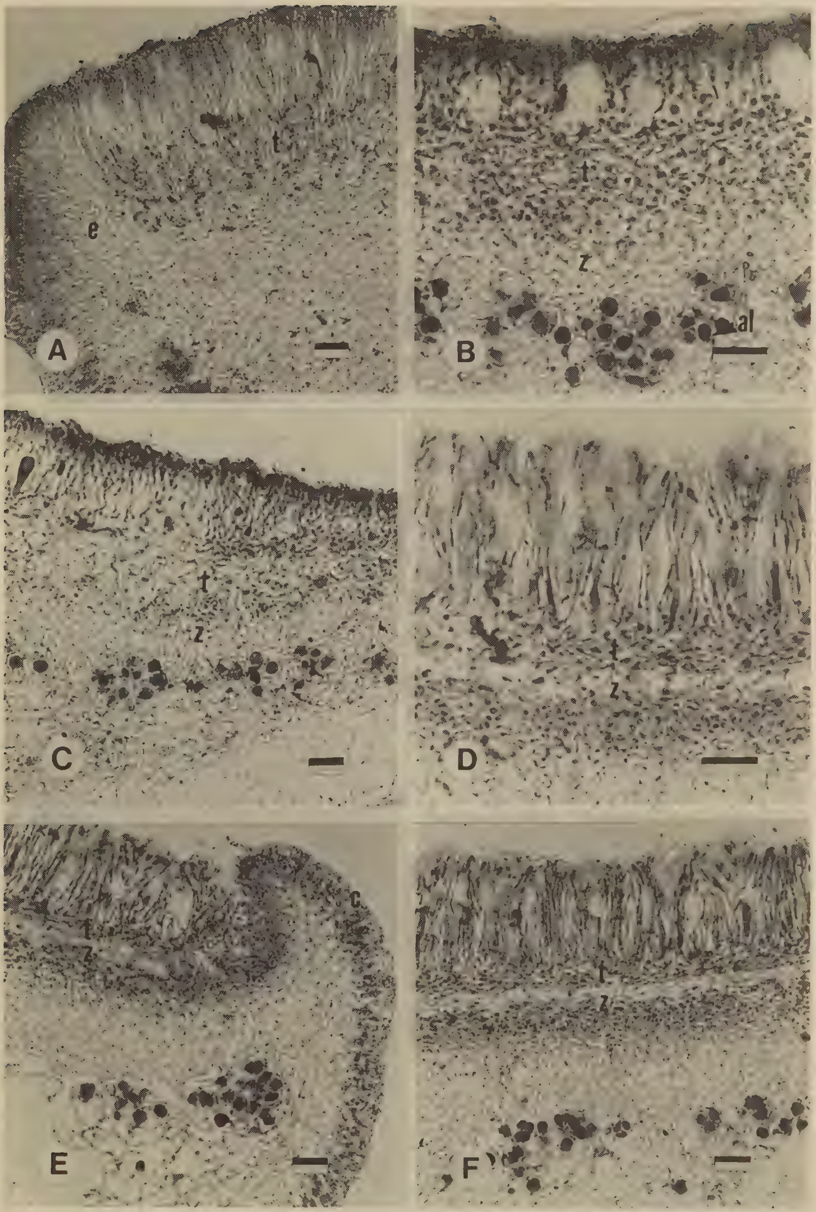
---

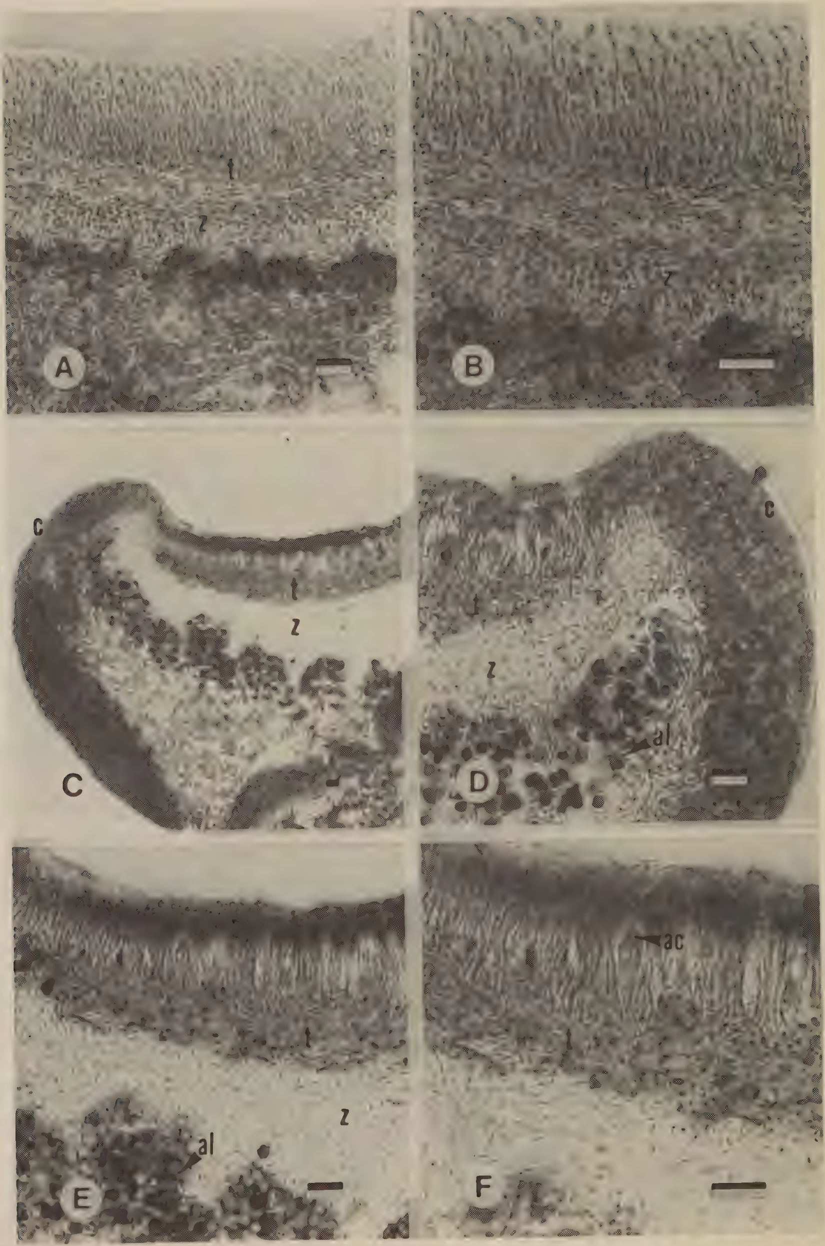
Figure 1. *Lecanora opiniconensis.* **A-F**. Ontogeny of the ascomata. Explanations in the text. ac = ascus; ah = ascogenous hyphae; al = algal cells; as = ascogonia; pl = central plexus; pr = paraphysoids. (Scale = 20μm).

Figure 2. *Lecanora opiniconensis.* **A-F**. Ontogeny of the ascomata. Explanations in the text. al = algal cells; c = apothecium cortex; t = hypothecium; y = hymenium; z = cupular excipulum. (Scale = 20μm).


al
as
A
as
pl
B
pl
C
pl
D
pr
ah
E
pr
ac
F


z
al
A
z
B
c
t
z
C
c
z
t
al
D
c
t
z
E
t
z
F


A
t
e
B
t
z
p
al
C
t
z
D
t
z
E
t
z
c
F
t
z


t
z
A
t
z
B
c
t
z
C
c
t
z
al
D
t
z
al
E
ac
t
F

bodies of *Lecanora opiniconensis*, which shows morphological similarities with some morphotypes of *Rhizoplaca* species (BRODO 1986). A *Lecanora* and a *Pleurosticta* species were used for comparision with typical anatomy of the Lecanoraceae and Parmeliaceae, respectively. Our results are presented below.

Material and Methods

Material: Specimens of *Lecanora opiniconensis*, *L. polytropa*, *Omphalodium pisacomense*, *Omphalora arizonica*, *Pleurosticta acetabulum*, *Rhizoplaca chrysoleuca* and *Rhizoplaca melanophthalmua* from the herbaria ASU, ESS, H and the private collection of H.T. LUMBSCH (hb. LUMBSCH) were examined.

List of photographed specimens:

Lecanora opiniconensis BRODO: U.S.A., Wisconsin, Sauk Co., 1 mi N of intersection of Hwys. U + 33, 31.5.1968, T.W. THOMSON 14558 (H); U.S.A., S Dakota, Black Hills, Meade Co., 2.5 mi E of Piedmont Butte, 30.6.1961, C.M. WETMORE 10389 (H) · — *L. polytropa* (HOFFM.) SCHAERER: Switzerland, Graubünden, Unterengadin, TK 25: 1199 Scurl, Greala, 2500 m alt, 8.9.1988 H. MIETZSCH 6287a (hb. LUMBSCH) · — *Omphalodium pisacomense* MEYEN & FLOT.: Argentina, Prov. Rio Negro, Depto, Pilcaniyen: ca 3 km E of Pilcaniyen, 3.11.1983, L. HÄMET-AHTI 3322 (H) · — *Omphalora arizonica* (TUCK. ex WILL.) NASH & HAFELLNER: U.S.A., Arizona, Santa Cruz, Santa Rita Mountains, Trail from Josephine Pass to Mount Wrightstone, 11.11.1973, T.H. NASH 8274 (H) · — *Pleurosticta acetabulum* (NECK.) ELIX & LUMBSCH: Italy, Sardinia, Anela, 700 m, 15.5.1989, G.B. FEIGE 5378 (ESS) · — *Rhizoplaca chrysoleuca* (SM.) ZOPF: Spain, Canary Islands, Tenerife, Las Cañadas, 2.1984, G.B. FEIGE 2701 (ESS) · — *R. melanophthalma* (RAM.) LEUCKERT & POELT: Spain, Sierra Nevada, Picoveleta, 9.1969, KRACH 1087 (ESS).

Methods. Samples were sectioned in 18 - 22 μm thickness using a freezing microtome. The sections were mounted in lactophenol cotton-blue. A Leitz Dialux 20 compound microscope was used for micrography of sections.

Figure 3. Apothecium anatomy. **A.** *Lecanora polytropa;* **B&C.** *Omphalodium pisacomense*; **D-F.** *Omphalora arizonica.* Explanations in the text. al = algal cells; c = apothecium cortex; e = annular excipulum; t = hypothecium; z = cupular excipulum. (Scale = 20μm).

Figure 4. Apothecium anatomy. **A&B.** *Pleurosticta acetabulum*; **C-F.** *Rhizoplaca chrysoleuca.* Explanations in the text. ac = ascus; al = algal cells; c = apothecium cortex; t = hypothecium; z = cupular excipulum. (Scale = 20μm).

Results and Discussion

The development of the ascomata in *Lecanora opiniconensis* is gymnocarpous and no trichogynes were found. In the first stage of development to be observed, slightly curved ascogonia are embedded in a network of a few hyphae (Fig. 1A). These ascogonia are situated in the algal layer below the upper cortex of the thallus. A compact globose primordium is formed in the lower part of the algal layer with centrally situated ascogonia in a heavily gelatinized central plexus (Fig. 1B). This compact primordium grows (Fig. 1C+D) and the hyaline gelatinized matrix is easily visible even at this stage of development. Later, the ascogenous hyphae appear within the short celled tissue of the paraphysoids *in statu nascendi* (Fig. 1E). Subsequently the paraphysoids are expanded and young asci appear (Fig. 1F).

In the process of maturing the paraphysoids were replaced by true paraphyses and the hymenium can be clearly seen by the formation of a hypothecium sensu CORNER (1929). The cupular excipulum is very well developed and surrounded by a thalline layer filled with a number of photobiont cells (Fig. 2A&B). At this stage the growth of the fruiting body becomes lateral (Fig. 2C). The paraphysoids at the border of the hymenium and excipulum persist at the margins (Fig. 2D). The special structure of the parmelioid ascoma is also visible in mature apothecia. Below the hymenium and hypothecium we find the relatively thick and light cupular excipulum surrounded by a thalline layer with many algal cells (Fig. 2E&F).

For comparision we examined some further usnic acid containing members of the Lecanoraceae and Parmeliaceae.

Lecanora polytropa has a lecanorine apothecium (Fig. 3A) with a small layer of slightly branched paraphyses at the margins of the hymenium ("parathecium") and a well developed thallus margin ("amphithecium"), but no cupular excipulum as found in *"L." opiniconensis*. These results agree with those by HENSSEN et al. (1981), who studied *L. argentata* (ACH.) DEGEL. (as *"L. subfuscata"*).

As a typical member of the Parmeliaceae we used *Pleurosticta acetabulum* for comparision, which was only recently (LUMBSCH et al. 1988) segregated from *Melanelia*, because of a pored epicortex, the bacilliform to fusiform conidia and an alternative chemistry. Some European authors still prefer to include these genera within the collective genus *Parmelia*. In this lichen the typical apothecial anatomy of the Parmeliaceae is shown (Fig. 4A&B).

In *Omphalodium pisacomense* a cupular excipulum is formed and the structure of the fruiting bodies closely resembles the typical Parmeliaceae ascoma anatomy (Fig. 3B&C). HALE (1985) doubted that *Omphalodium* s. str. belonged to the Parmeliaceae and proposed that it might be better placed within the Umbilicariaceae. His opinion was based mainly on the growth form and the medullary chemistry. However, our results confirm that *Omphalodium* s. str. is best placed in the Parmeliaceae, since the ontogeny and anatomy of the ascomata in the Umbilicariaceae differ significantly from the Parmeliaceae (HENSSEN 1970).

In the recently described monotypic genus *Omphalora* (NASH et al. 1990) we also found the Parmeliaceae type of ascoma anatomy (Fig. 2D-F). This supports the view of BELTMAN (1978), HENSSEN et al. (1981) and NASH et al. (1990), that *Omphalora arizonica* belongs to the Parmeliaceae. In this lichen we observed a differentiation between the cupular excipulum in an upper hyaline layer and a lower part with a number of more or less pseudoparenchymatic cells with thin walls.

The genus *Rhizoplaca* is usually placed in the heterogenous family Lecanoraceae (POELT & VĚZDA 1981, HAFELLNER 1984, ERIKSSON & HAWKSWORTH 1987). However, our studies show that *R. chrysoleuca* possesses an excipulum of the Parmeliaceae type (Fig. 4C-F). This is also true for *R. melanophthalma* so we now propose to transfer *Rhizoplaca* from the Lecanoraceae to the Parmeliaceae.

The systematic position of *"Lecanora" opiniconensis* remains uncertain. While its position within the Parmeliaceae should not be questioned, we hesitate to describe a new genus until we have a better understanding of several other groups of taxa within *Lecanora* subgenus *Placodium*. Moreover the relationship between *"L." opiniconensis* and the arctic-boreal genus *Arctopeltis* (POELT 1983) and *Rhizoplaca* has to be carefully reexamined. BRODO (1986) previously described some morphological similarities between *"L." opiniconensis* and morphotypes of *R. chrysoleuca.*

The growth form of *"L." opiniconensis* is quite remarkable for the Parmeliaceae and it is one of the few placodioid members of the family. However, the Parmeliaceae are well known for their morphological variation (HENSSEN & JAHNS 1973). The family contains fruticose, foliose as well as umbilicate taxa. Thus the incorporation of *Rhizoplaca* in the Parmeliaceae is not surprising and HALE (1989) has previously included adnate and subcrustose species in the new genus *Karoowia* within the Parmeliaceae.

Further studies of some groups within the heterogenous genus *Lecanora* will undoubtely reveal that some taxa actually belong to the Parmeliaceae.

Acknowledgements

We wish to thank Dr. T.H. NASH III (Tempe) and Mr. O. VITIKAINEN (Helsinki) for the loan of specimens. We are grateful to Dr. J.A. ELIX (Canberra) for his comments on our manuscript.

Literature

BELTMAN, H.A. (1978) Vegetative Strukturen der Parmeliaceae und ihre Entwicklung. *Bibl. Lichenol.* **11**: 1-193.

BRODO I.M. (1986) A new lobate species of the lichen genus *Lecanora* (Ascomycotina, Lecanoraceae) *Mycotaxon* **26**: 309-317.

CORNER, E.J.H. (1929) Studies in the morphology of discomycetes I. The marginal growth of apothecia. *Trans. Br. Mycol. Soc.* **14**: 261-274.

ERIKSSON, O.E. & D.L. HAWKSWORTH (1987) Outline of the Ascomycetes - 1987. *Systema Ascomycetum* **6**: 259-337.

HAFELLNER, J. (1984) Studien in Richtung einer natürlichen Gliederung der Sammelfamilien Lecanoraceae und Lecideaceae. *Beih. Nova Hedwigia* **79**: 241-371.

HALE, M.E. (1985) *Xanthamaculina* HALE, a new genus in the Parmeliaceae (Ascomycotina). *Lichenologist* **17**: 255-265.

HALE, M.E. (1989) A monograph of the lichen genus *Karoowia* HALE (Ascomycotina: Parmeliaceae). *Mycotaxon* **35**: 177-198.

HENSSEN, A. (1970) Die Apothecienentwicklung bei *Umbilicaria* HOFFM. emend. FREY. *Dtsch. Bot. Ges.* N.F. **4**: 103-126.

HENSSEN, A. & H.M. JAHNS (1973) ("1974") *Lichenes: Eine Einführung in die Flechtenkunde.* Stuttgart, Thieme Verlag.

HENSSEN, A., G. KEUCK, B. RENNER, & G. VOBIS (1981) The Lecanoralean Centrum. In: *Ascomycete Systematics. The Luttrellian Concept.* (D.R. REYNOLDS, ed.): 138-234. New York, Heidelberg & Berlin, Springer Verlag.

HILLMANN, J. (1936) Parmeliaceae. *Rabenh. Krypt. Fl.* **9** (5,3): 1-309.

LETROUIT-GALINOU, M.A. & R. LALLEMANT (1970) Les apothécies et les asques du *Parmelia conspersa* (Discolichen, Parmeliacée). *Bryologist* **37**: 39-58.

LUMBSCH, H.T., H.W. KOTHE & J.A. ELIX (1988) Resurrection of the lichen genus *Pleurosticta* PETRAK (Parmeliaceae: Ascomycotina). *Mycotaxon* **33**: 447-455.

NASH III, T.H., J. HAFELLNER & R.S. COMMON (1990) *Omphalora,* a new genus in the Parmeliaceae. *Lichenologist* **22**: 355-365.

NYLANDER, W. (1858/69) *Synopsis Methodica Lichenum.* Paris, L. Martinet.

POELT, J. (1983) Über den Formenkreis der Flechte *Lecanora contractula. Int. J. Myc. Lich.* **1**: 143-160.

POELT, J. & A. VĚZDA (1981) Bestimmungsschlüssel europäischer Flechten. Ergänzungsheft 2. *Bibl. Lichenol.* **16**: 1-390.

ZAHLBRUCKNER, A. (1926) Lichenes. B. Spezieller Teil. In: *Die natürlichen Pflanzenfamilien* (A. ENGLER & K. PRANTEL, ed.). Bd. 8, 2nd ed. Leipzig, Bornträger Verlag.

MYCOTAXON

Volume XLII, pp.89-93 October-December 1991

DEMATIACEOUS HYPHOMYCETES ON FREYCINETIA (PANDANACEAE). 3. CHALARODES GEN. NOV.

E.H.C. McKENZIE

DSIR Plant Protection
Private Bag, Auckland, New Zealand

Abstract

A new hyphomycete genus, *Chalarodes*, is described and figured. It is based on two species found on dead leaves of *Freycinetia* spp.; *C. bisetis* occurs in New Zealand, and *C. obconica* in New Caledonia. The genus is similar to *Chalara* but has distinctive obconical conidia each with two apical setulae.

Introduction

During an examination of 62 samples of dead *Freycinetia* leaves from eight countries (McKenzie 1991), a new hyphomycete genus with similarities to *Chalara* (Corda) Rabenh. was found. Two species from the genus are described. All specimens are deposited in the herbarium of DSIR Plant Protection (PDD).

Chalarodes gen. nov.
Deuteromycotina, Hyphomycetales

Conidiophora macronematosa, mononematosa, solitaria, eramosa, erecta, septata, brunnea. Cellulae conidiogenae monophialidicae, in conidiophoris incorporatae, terminales. Conidia endogena, catenulate extrusa, obconica, hyalina, eseptata, apicaliter bisetulosa.

Species typica: *Chalarodes bisetis* McKenzie

Conidiophores macronematous, mononematous, single, unbranched, erect, septate, brown. Conidiogenous cells monophialidic, integrated, terminal. Conidia endogenous, catenate, obconical, hyaline, non-septate, bearing 2 setulae at the distal end.

Etymology: Greek suffix -odes; meaning like, *Chalara*, from which *Chalarodes* is distinguished.

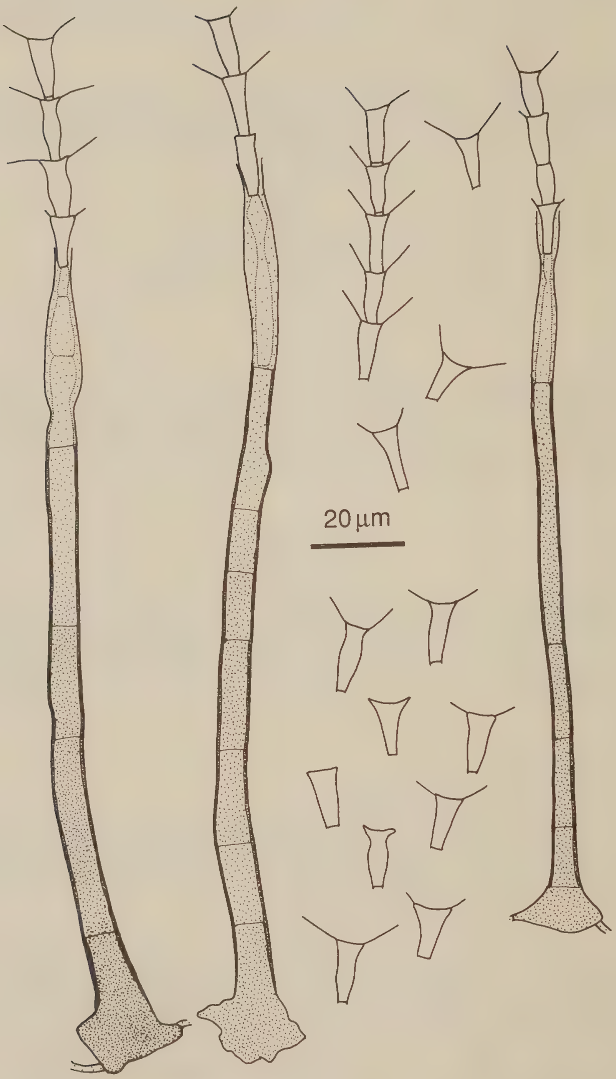


Figure 1. *Chalarodes bisetis*, conidiophores and conidia from host (PDD 57220, type). Specimen mounted in hydrous lactophenol.

Chalarodes bisetis McKenzie sp. nov. Fig. 1

Mycelium internum. Conidiophora macronematosa, mononematosa, solitaria, eramosa, erecta, recta vel paulo flexuosa, laevia, septata, brunnea, apicem versus pallidiora, usque ad 400 μm longa x 5-10 μm crassa; e cellulis brunneis, laevibus, basi plerumque ad 25 μm inflatis. Cellulae conidiogenae monophialidicae, in conidiophoris incorporatae, terminales, urceolatae, pallide brunneae, 32-55 x 5-7.5 μm; collum cylindricum vel obconicum, basi 3-4 μm latum, apice 4-5 μm latum. Conidia endogena, catenulate extrusa, obconica, hyalina, laevia, eseptata, (9.5-) 12-14 (-15) μm longa, apice 4.5-6 (-9) μm lata, basi truncata, 2-3 μm lata, saepe fimbriam marginalem ferente, apicaliter bisetulosa.

In foliis mortuis pandanaceae *Freycinetia baueriana* Endl. ssp. *banksii* (Cunn.) Stone
Holotypus PDD 57220.

Mycelium immersed. Conidiophores originating from brown, smooth, usually swollen cells up to 25 μm wide; macronematous, mononematous, single, unbranched, erect, straight or slightly flexuous, smooth, septate, brown, paler towards the apex, up to 400 μm long x 5-10 μm thick. Conidiogenous cells monophialidic, integrated, terminal, urceolate, pale brown 32-55 μm long x 5-7.5 μm wide; collarette cylindrical or obconical, 3-4 μm wide at base, 4-5 μm at apex. Conidia endogenous, catenate, obtriangular, hyaline, smooth, non-septate, (9.5-) 12-14 (-15) μm long x 4.5-6 (-9) μm wide at the apex, and 2-3 μm at the truncate base, often with a basal marginal frill, distal end bearing 2 setulae each up to 10 μm long x c. 0.25 μm wide.

On *Freycinetia baueriana* Endl. ssp. *banksii* (Cunn.) Stone
Specimens examined: **New Zealand**, AUCKLAND, Waitakere Ranges, Spraggs Bush, 19.IV.1987, R.E. Beever (PDD 57220 - **holotype**). COROMANDEL, Kauaeranga Valley, Tarawaere Dam Track, 1.IX.1986, E.H.C. McKenzie (PDD 57203); Little Barrier Island, Summit Track, 7.IV.1988, E.H.C. McKenzie (PDD 57202); P.R. Johnston (PDD 57204). BAY OF PLENTY, Kaimai-Mamaku Forest Park, Tuahu Track, 11.VI.1985, G.J. Samuels, P.K. Buchanan (PDD 57200). WAIKATO, near Kawhia, Te Kauri Reserve, 20.V.1988, E.H.C. McKenzie (PDD 57201); Mt Pirongia, Track 1, 27.III.1984, E.H.C. McKenzie (PDD 57205). WANGANUI, Bushy Park, 16.V.1987, E.H.C McKenzie, P.R. Johnston (PDD 57221).

The specific epithet refers to the two setulae on the conidia.

Chalarodes obconica McKenzie sp. nov. Fig. 2

Mycelium internum. Conidiophora macronematosa, mononematosa, solitaria, eramosa, erecta, recta vel paulo flexuosa, laevia, septata, brunnea, apicem versus pallidiora, usque ad 220 μm longa x 5-7 μm crassa; e cellulis fuscis, laevibus, basi saepe ad 25 μm inflata, radialiter lobata. Cellulae conidiogenae monophialidicae, in conidiophoris incorporatae, terminales, urceolatae, pallide brunneae, 30-36 x 5-7 μm; collum obconicum, basi 2.75-3 μm latum, apice 4.5-5.5 μm latum. Conidia endogena, catenulate extrusa,

late obconica, hyalina, laevia, eseptata, (8-) 9-10.5 (-11) μm longa, apice (7.5-) 8.5-10.5 μm lata, basi truncata, 1.75-2 μm lata, apicaliter bisetulosa.

In foliis mortuis pandanaceae *Freycinetia ?graminifolia* Solms et *Freycinetia* sp.
Holotypus PDD 58421.

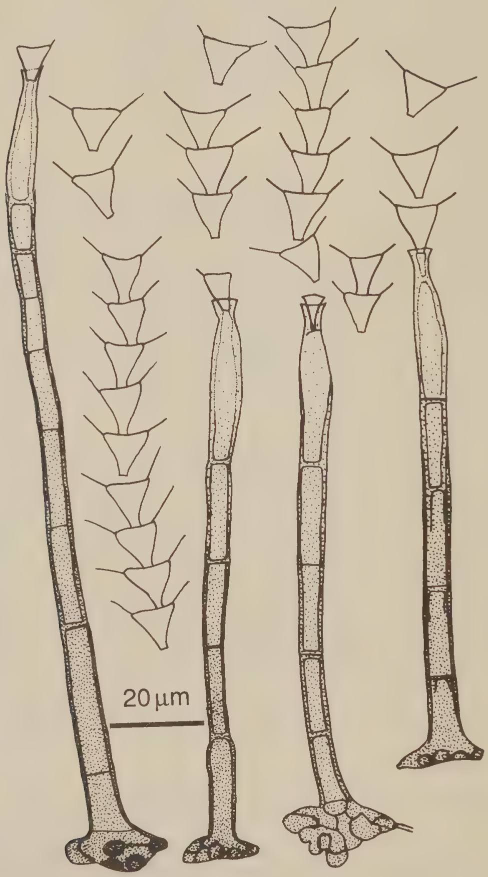


Figure 2. *Chalarodes obconica*, conidiophores and conidia from host (PDD 58421, type). Specimen mounted in hydrous lactophenol.

Mycelium immersed. Conidiophores originating from dark brown, smooth, often swollen and radially lobed cells up to 25 μm wide; macronematous, mononematous, single, unbranched, erect, straight or slightly flexuous, smooth, septate, brown, paler towards the apex, up to 220 μm long x 5-7 μm thick. Conidiogenous cells monophialidic, integrated, terminal, urceolate, pale brown 30-36 μm long x 5-7 μm wide, collarette obconical, 2.75-3 μm wide at base, 4.5-5.5 μm at apex. Conidia endogenous, catenate, broadly obtriangular, hyaline, smooth, non-septate, (8-) 9-10.5 (-11) μm long x (7.5-) 8.5-10.5 μm wide at the apex, and 1.75-2 μm at the truncate base, distal end bearing 2 setulae each 5 (-7) μm long x c. 0.25 μm wide.

On *Freycinetia ?graminifolia* Solms
Specimen examined: **New Caledonia**, Mt Panié, 1300m, 15.XII.1990, J.S. Dugdale (PDD 58421 -**holotype**).
On *Freycinetia* sp.
Specimen examined: **New Caledonia**, Mt Panié, 1500m, 15.XII.1990, J.S. Dugdale (PDD 58422).

The specific epithet refers to the shape of the conidia.

Chalara is a well-defined genus producing cylindrical or less frequently subcylindrical, unicellular or septate, non-setulate phialoconidia. There are some similar genera, and it has been suggested that *Chalara* and its setose equivalent, *Chaetochalara*, be merged (Kendrick 1980). Nag Raj & Kendrick (1975) recognised 61 species of *Chalara* together with some *Chalara* anamorphs of *Ceratocystis* and of *Cryptendoxyla*, and 6 species of *Chaetochalara*. Since then at least 24 additional species of *Chalara* and one of *Chaetochalara* have been described, but none has setulate conidia. The presence of setulae and the distinctive obconical shape of the conidia justify the erection of a separate, distinct genus.

Acknowledgement

I gratefully acknowledge the assistance of Dr G. Kuschel in the preparation of the Latin diagnoses. I thank Professor Gareth Morgan-Jones, Department of Plant Pathology, College of Agriculture, Auburn University, Auburn, Alabama, USA for critical review of this paper.

References

Kendrick, B. 1980: The generic concept in hyphomycetes - a reappraisal. *Mycotaxon 11*: 339-364.
McKenzie, E.H.C. 1991: Dematiaceous hyphomycetes on *Freycinetia* (Pandanaceae). 1. *Stachybotrys*. *Mycotaxon 41*: 179-188.
Nag Raj, T.R.; Kendrick, B. 1975: A monograph of *Chalara* and allied genera. Waterloo, Ontario, Canada, Wilfrid Laurier University Press.

MYCOTAXON

Volume XLII, pp. 95-97 October-December 1991

CAPITOROSTRUM COCOES SP. NOV., CAUSING LEAF SPOT OF COCOS NUCIFERA

KEVIN D. HYDE[1] & ELIJAH PHILEMON[2]

[1]*Plant Pathology Branch, Queensland Department of Primary Industries, Mareeba 4880, Australia.*

[2]*Department of Agriculture and Livestock, Agricultural Products Division, P.O. Box 2141, Boroko, PNG.*

Abstract

Capitorostrum cocoes Hyde *et* Philemon sp. nov. is described from leaf spots of *Cocos nucifera*. The taxon is compared with *C. asteridiellae* which has smaller conidia and was associated with colonies of *Asteridiella* on *Cryptocarya*.

During a recent survey of the plant pathogens of the Western Province of Papua New Guinea, a fungus associated with leaf spots of *Cocos nucifera* L. was collected. The fungus, *Capitorostrum cocoes* sp. nov., is described and illustrated in this paper.

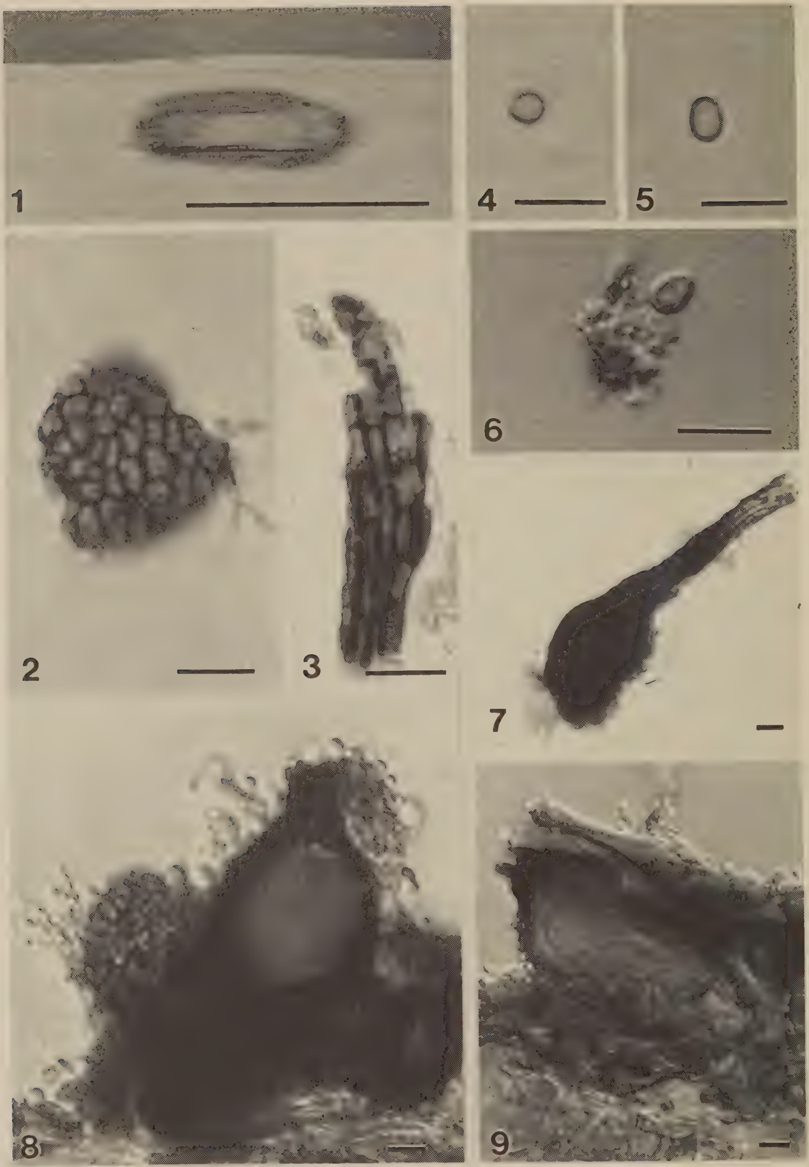
TAXONOMY

CAPITOROSTRUM COCOES Hyde *et* Philemon, sp. nov. Figs 1-9.

Etym.: from the host *Cocos*.

Conidiomata 78-110 μm alta, 24-64 μm diam, pycnidialia, superficialia, ad basim immersa, unilocularia, solitaria vel aggregata, separata, ostiolata, ad basim subglobosa. Collum longum et pachydermum. Sine *conidiophora*. *Cellulae conidiogenae* 3-4 μm diam, 'phialidicae', ampulliformes, hyalinae. *Conidia* 1.6-2.4 x 1.4-1.8 μm, pallide brunnea, ellipsoidea, unicellularia, eguttulata.

Conidiomata 78-110 μm high, 24-64 μm diam, pycnidial, superficial, but with an immersed base, solitary or clustered, separate, subglobose at the base, unilocular, basal wall up to 10 μm thick, of thin-walled brown textura angularis. *Ostiole* single, circular. Neck up to 12 μm diam, of parallel brown textura prismatica. *Conidiophores* absent. *Conidiogenous cells* 3-4 μm diam, phialidic (*sensu* Sutton, 1980), ampulliform, hyaline, smooth, channel and collarette minute, formed from



Figs. 1-7. *Capitorostrum cocoes*. Fig. 1. Leaf spot. Figs. 2-7. Interference light contrast micrographs. Fig. 2. External surface of conidioma wall. Fig. 3. Neck. Figs. 4,5. Conidia. Fig. 6. Conidiogenous cell and conidium. Fig. 7. Conidioma. Figs. 8,9. Vertical sections through conidiomata. The bases are immersed in the host tissue. Bar Lines: 1 = 10 mm, 4-6 = 5 μm, 2,3,7-9 = 10μm.

the base of the pycnidial wall. *Conidia* 1.6-2.4 x 1.4-1.8 μm, light-brown, smooth, aseptate, eguttulate, ellipsoid. Associated with oval brown necrotic leaf spots on *Cocos nucifera*.

Holotype: Papua New Guinea, Western Province, Wipim, on leaf spot of *Cocos nucifera*, April 1990, K.D. Hyde and E. Philemon, BRIP 17443.

The genus *Capitorostrum* Bastista apud Bastista and Maia (1957) is monotypic. The type species *C. asteridiellae* Batista was described by Sutton (1980). *Capitorostrum cocoes* differs from *C. asteridiellae* in its smaller conidial size and its host, as the latter was found associated with colonies of *Asteridiella* fraseniana on *Cryptocarya meissneri* (Sutton, 1980). Similarities include the long necked conidiomata, conidiogenous cells and conidia and these warrant inclusion of the species in *Capitorostrum*. The bases of the conidiomata of *C. cocoes* are immersed in the host tissue (Figs. 8,9), indicating a necrotrophic mode of life.

ACKNOWLEDGEMENTS

We would like to thank Dr. B.C. Sutton for discussions on this fungus and for commenting on the manuscript. We are also grateful to the Northern Australian Quarantine Survey (NAQS) and Australian Quarantine Inspection Service (AQIS) for funding this research.

LITERATURE CITED

BATISTA, A.C. and MAIA, H.S. 1957. Um grupo de fungos hiperparasitas Rev. Biologia, Lisboa 1:140-156.

SUTTON, B.C. 1980. The Coelomycetes. Kew, Surrey, England: CAB International Mycological Institute.

MYCOTAXON

Volume XLII, pp. 99-123 October-December 1991

A PHYLOGENY OF FISSITUNICATE ASCOSTROMATIC FUNGI

DON R. REYNOLDS
NATURAL HISTORY MUSEUM
900 EXPOSITION BOULEVARD
LOS ANGELES, CALIFORNIA 90007 USA

1. ABSTRACT

An ascostroma and *Meliola* , extenditunicate, rostrate, and fissitunicate, ascus types characterize the ascostromatic ascomycetes. The latter two types constitute the "bitunicate ascus" of the loculoascomycetes. A working hypothesis of phylogeny regards the ascostromatic ascus type as a synapomorphic character for respective monophyletic clades. This phylogeny study is limited to the fissitunicate taxa. Parsimony and Character Compatibility methods are used for both ordinal and familial taxa. M. E. Barr's 1987 classification for the loculoascomycetes is used for taxon definition. The Myriangiales and the Myriangiaceae are the outgroup references. The traditionally weighted hamathecial characters constrain the relationships of ordinal taxa. The family level analysis indicate monophyletic groups formed from several homo- and heterogenous groups in the Melanommatales and in the Pleosporales, and the Capnodiales and the Chaetothyriales. The Dothideales appears to be polyphyletic, suggesting a historic inability to recognize the true relationship of these taxa from morphological characters. Conclusions include a recommendation that the term “loculoascomycetes” should be abandoned, and observations that Barr’s ordinal definitions are unsupported by this study and that the hamathecium characters are imprecise indicators of natural groups in the ascostromatic ascomycetes.

2. INTRODUCTION

A single character, the ascostroma, is the basis of recognition of the ascostromatic ascomycetes. The concept of this ascocarp derives from its formation of somatic hyphae before the initiation of the sexual process. The alternative type is the "true" ascocarp formed from hyphae associated with the developmental process leading to meiosis. Nannfeldt (1932) used this ascocarp type to recognize the ascoloculares, with asci formed in a stromatal cavity, and the ascohymeniales, with the asci formed in the true ascocarp.

The ascomata concept enlarged with the association of an ascus type with the ascocarp type termed "bitunicate." Luttrell (1951) linked this ascus type to the ascostroma and associated the "unitunicate" ascus with the true ascocarp. The ascostromatic ascomycetes were subsequently defined as the Loculoascomycetes (1955) by the ascostroma and bitunicate ascus characters.

The use of Luttrell's concept of the loculoascomycetes concept for ascostromatic fungi classification led to the inclusion of over 9,500 of the known ascomycete species in the Class Loculoascomycetes (Hawksworth et al., 1983). In the almost four decades since the establishment of the Loculoascomycetes, a conflict has developed concerning a modern classification of the ascostromatic ascomycetes. The disagreement is amply illustrated in two contemporary assessments. One extreme is M. E. Barr's 1987 work entitled, "Prodromous to the Loculoascomycetes." Barr required two supradivisons, three divisions, six classes, 9 subclasses and 10 orders to organize 55 families. The contrast is von Arx and Müller's (1975) "reevaluation of the bitunicate ascomycetes" where all the taxa were placed in one order the Dothideales. The solution offered in the 1989 version of the "Outline of the Ascomycetes" compiled by O. Eriksson and D. H. Hawksworth (1990) was to assign these fungi to mostly one of 5 orders, the Dothideales, with no supraordinal taxa recognized.

3. ASCOSTROMATIC ASCUS TYPES

Luttrell's loculoascomycetes comprise a polyphyletic group. This view is supported by the occurrence of several types of asci in the ascostroma rather than just the bitunicate one. These ascostromatic ascus types are postulated as the most informative source of characters for recognition of monophyletic groups in the loculoascomycetes.

Phylogenetically important characters can likely derive from ascus development and its subsequent function as a spore dispersal phenomenon. The ascus wall develops in two basic stages. The meiosporangium with a diploid nucleus undergoes growth within a primary wall boundary to a characteristic dimension. A secondary wall of one or more layers forms on the inner surface of the primary wall at this point. Ascosporogenesis usually occurs at this point and ascospore ejaculation eventually follows. The major ascus characters are derived from the secondary wall, and the corresponding changes that the wall undergoes during ascospore formation and dispersal. The reference character is a layer that French workers have termed "Couche D." This layer is composed of wall components that are initially packed so that its modification, usually expansion, can occur during ascosporogenesis and primarily during ascospore ejaculation. The Couche D expands only during ascosporogenesis in the extenditunicate ascus (Reynolds, 1989a), is everted to form a spore escape tube in the rostrate ascus (Reynolds, 1987), and projects to form a tube that separates from the primary wall in the fissitunicate ascus (Reynolds, 1971, 1989b).

3.1. Extenditunicate Ascus.

Couche D is a secondary wall formation; the ascus appears thick walled with light microscopic resolution at this stage. Couche D expands during ascosporogenesis with a corresponding thinning of this secondary wall. No extension of the ascus wall occurs at the time of ascospore ejaculation (Reynolds, 1989a). Examples of ascostromatic ascomycetes with the extenditunicate ascus are the genera *Meliolina* and *Trabutia* .

3.2. Rostrate Ascus.

Couche D is well developed at the apex of the ascus; sometimes the nasse apical illusion can be seen. Couche D forms an ascospore escape tube by everting through a split in the primary wall (Reynolds, 1987). The semifissitunicate ascus (Eriksson, 1981) is essentially an elongate rostrate ascus with an additional feature of a separation between two wall layers in the apical area where Couche D occurs. Rostrate examples (Barr, 1987): Orders Arthoniales, Asterinales, Myriangiales (Families: Seuratiaceae, Schizothyriaceae).

3.3. Fissitunicate Ascus.

Couche D develops well at the apex of the ascus and laterally. A tubular chamber in the secondary wall apex, the "nasse apicale", often produces a spiral refraction at the interface with the cytoplasm because of the configuration of the wall surface. At the time of ascospore ejaculation, the ascus wall breaks apically at the primary and secondary wall interface and separates into two layers; Couche D expands into an ascospore escape tube by projecting from its apical and outer boundary (Reynolds, 1971; 1989B). Fissitunicate examples: Orders: Capnodiales, Chaetothyriales, Dothideales, Myriangiales (Families: Cookellaceae, Elsinoaceae, Myriangiaceae), Opegraphales, Patellariales, Pleosporales, and Melanommatales.

3.4. The *Meliola* ascus.

Luttrell (1989) demonstrated the ascostromatic nature of the ascocarp in *Meliola*. He also refused to acknowledge the fungus as a member of his Loculoascomycetes because of the thin walled ascus. This was the attitude toward other exceptions in his original work (Luttrell, 1951). The ascus of this fungus apparently lacks the Couche D. Because the ascus enlarges during ascosporogenesis, the primary wall is the likely site of wall expansion (Reynolds, 1989).

3.4 Ascus evolution.

A parsimony analysis of the ascus character suite provides a sense of historical development. *Meliola* is included as an ascus without Couche D, but with an ascostroma; this ascus type is presumed ancestral.

Character 1 Primary wall expand during ascosporogenesis
Character 2 Couche D present, no extension
Character 3 Couche D extends as eversion
Character 4 Couche D extends as an extension from apex
Character 5 Wall separation as two layers in Couche D area

The ascus types were scored for characters 1-5 as follows: *Meliola* 10000, Extenditunicate 11000, Rostrate 10100, Fissitunicate 10010, and Semifissitunicate 10101.

Four derived relationships are possible with parsimony analysis of the ascus characters. In one topology the extenditunicate ascus is ancestral to the Rostrate, fissitunicate, and semifissitunicate ascus types. In a second topology other topologies, a polychotomy is formed of the extenditunicate, rostrate and fissitunicate ascus. Four trees are formed from the two topologies by the semifissitunicate ascus alternately shown as derived from the rostrate ascus or from the fissitunicate ascus.

The prediction of monophyletic ascostromatic groups with an ascus type indicates that the extenditunicate group could be ancestral to the rostrate and fissitunicate groups. The lichenized fungi with the fissitunicate ascus are likely derived from the rostrate ascus group as a separate line from the fisstunicate group or through common antecedents. Clearly, more data are needed to further test this hypothesis.

4. CHARACTERS

The characters are arranged in suites of similar attributes, ranging in size from 1-9 attributes. Each suite is scored as a separate character rather than as a transition series. Homology is not assumed for characters so grouped, but rather a similarity of morphology or function.

Character 1. The ascus type. One ascus type, the fissitunicate, is used for the data set; the ascus type of the Elsinoaceae, included in the Myriangiales, was shown by Gabel and Tiffany (1987) to be fissitunicate. Several species in the Myriangiaceae and Cookellaceae were included in an unverified list of fissitunicate asci (Reynolds, 1989b). 0=no, 1=yes.

Characters 2-3. Ascus position in the ascocarp.

Character 2. The asci form a hymenial layer 0=No, 1=yes.
Character 3. The asci are scattered in the ascocarp. 0=no, 1=yes.

Characters 4-8. Hamathecium. The term "hamathecium" was defined by Eriksson (1981) as "gr., hama = together with, thecium = a small case" with the meaning to "cover all kinds of hyphae or tissue between the asci or projecting into the locule or ostiole." The hamathecium types recognized were 1) interascal pseudoparenchyma = tissue remaining unchanged or becoming compressed between developing asci (*Pseudosphaeria* and *Wettsteinina* were the examples. 2) paraphysoids = trabecular pseudoparaphyses and tinophyses - interascal or preascal tissue stretching and coming to resemble pseudoparaphyses (Melanomma). 3) paraphyses = hyphae originating from the bottom of the cavity (*Pyrenula*). 4) pseudoparaphyses or cataphyses = originating from the epihymenial cupola and growing down between the developing asci to the bottom of the cavity, finally anchoring to the bottom and often becoming free in the upper part of the cavity (*Pleospora*). 5) Periphysoids = short hyphae form the epihymenial cupola not reaching the bottom of the cavity (*Limacinia*). 6) periphyses = hyphae in the ostiolar channel, sometimes found with periphysoids. 7) no hamathecial hyphae (*Dothidea*).
4. Periphysoids: Filamentous, usually downward cellular extensions from the apical region of the ascocarp cavity, with free ends; 0=absent, 1=present.
5. Paraphysoids: Attached from base to apex in young apothecioid ascocarps that become free in the open mature fruit body; 0=absent, 1=present.

6. Cellular pseudoparaphyses: Broad or narrow, branched or not branched, sometimes anastomosing above the asci, at times deliquescent at full maturity; 0=absent, 1=present.
7. Trabeculae pseudoparaphyses: Barr (1987, pages 16, 117) defined these sterile elements as thin, distant from each other and embedded in a gel; she suggested that they are a type of periphysoid that project into the hymenial area; 0=absent, 1=present.
8. No hamathecium

Characters 9-13. Nutrition. Each family is characterized by one or more modes of nutrition.

9. Saprobic: 0=no, 1=yes.
10. Hemibiotic: Development is begun on living plant parts and complete the life cycle on nonliving parts; 0=no, 1=yes.
11. Semibiotic: These are lichenized taxa. 0=no, 1=yes.
12. Hyperparasitic: Parasitic on fungi; 0=no, 1=yes.
13. Biotrophic: Parasitic on plants; 0=no, 1=yes.

Characters 14-15. Ascospore shape. Ascospore characters were said to have validity in the diagnosis of a particular species or genus (Barr, page 16). Included in the Barr diagnoses were ascospore septation and bipolar symmetry; only the latter attribute is included in this study. Barr indicated that symmetry determines ascospore shape, and mentioned this character at ordinal and familial levels.

14. Symmetrical: 0=no, 1=yes.
15. Asymmetrical: 0=no, 1=yes.

Characters 16-19. Conidiogeny. Barr expressed reservations about proven pleomorphy (Barr, pages 17-18). Two basic types of conidium production, thallic and blastic hyphomycetes and coelomycetes.

16. Coelomycetes: 0=no, 1=yes.
17. Hyphomycete-blastic: 0=no, 1=yes.

18. Hyphomycete-phialidic: 0=no, 1=yes
19. Pleomorphy absent

Characters 20-22. Habitat. A superficial habitat was used as an ordinal level character (Barr, page 10).

20. Ascomata superficial on nonliving substrate
21. Ascomata superficial on living substrate.
22. Ascomata emersed/erumpent

Characters 23-30. Habit. The characters of the fruit body were said to be important at the family or genus level. Those used in this study are an elaboration of the first three "states" listed in Table II, and in Tables III and IV (Barr, pages 10-13).

23. Unilocular ascoma: Apothecial; 0=no, 1=yes.
24. Unilocular ascoma: Perithecial; 0=no, 1=yes.
25. Unilocular ascoma: Cleistothecial; 0=no, 1=yes.
26. Unilocular ascoma: Dimidiate/scutate; 0=no, 1=yes.
27. Unilocular ascoma: Lenticular; 0=no, 1=yes.
28. Unilocular ascoma: Hysterithycoid; 0-no, 1=yes.
29. Unilocular ascoma: Conchate; 0=no, 1=yes.
30. Polylocular ascoma: 0=no, 1=yes.

5. DATA MATRIX

The matrix is alphabetical by families. The families of the Capnodiales are scored in two ways. In one the hamathecial interpretation is that of Barr (1987) which does not recognize any sterile element. The second scoring is based on the interpretation of Reynolds (1979) which recognized periphysoids in the ascocarp.

The ordinal characters are a summary of the characters of the families assigned by Barr (1987) to a particular order. The outgroup is the family Myriangiaceae for the family level and the order Myriangiales for the orders. MYR=Myriangiales, PLE= Pleosporales, DOT=Dothideales, CHA=Chaetothyriales, CAP= Capnodiales, MEL=Melanommatales, OPE=Opegraphales, PAT= Patellariales. The analysis was done with PAUP (Swofford, 1990).

CHARACTER NUMBER	000000000111111111122222222223 123456789012345678901234567890
TAXA	
MYRCookellaceae	101000010001010000000000000000
MYRelsinoaceae	**111000010000110100000101000000**
MYRmyriangiaceae	101000011000010000001000000000
MYRIANGIALES	101000011001010000000000000000
CAPantennulariellaceae	110100001000010110001001000000
CAPcapnodiaceae	110100001000001101001001000000
CAPeuantennariaceae	110100001000001011001001000000
CAPNODIALES	110100001000011111001001000000
CAPantennulariellaceae	**110000011000010110001001000000**
CAPcapnodiaceae	**110000011000001101001001000000**
CAPeuantennariaceae	**110000011000011011001001000000**
CAPNODIALES	**110000011000011111001001000000**
CHAcoccodiniaceae	110100001000001000101001000000
CHAchaetothyriaceae	110100001000001000101001000000
CHAherpotrichiellaceae	110100001000010001010001000000
CHAmetacapnodiaceae	110100001000001010001001000000
CHAstrigulaceae	110100000010010100001001000000
CHAtrichopeltidaceae	110100001001010010001000001000
CHAETOTHYRIALES	110100001011011111111001001000
DOTdothideaceae	110000011100111110010101000000
DOTdothioraceae	110000010100110100000101000000
DOTkriegeriellaceae	110000011000011100010001000000
DOTlichenotheliaceae	110000011000011000100001000000
DOTmycoporaceae	110000011000000000110101000000
DOTpseudosphaeriaceae	110000011000110010011101000000
DOTHIDEALES	110000011100111110111101000000
MELacrocordiaceae	110000101010011000100101000000
MELdidymosphaeriaceae	110000101000011100000101100000
MELfenestellaceae	110000101100010000110101000000
MELmassariaceae	110000101100010000110101000000
MELmelanommataceae	110000101000010100010101000000
MELmicrothyriaceae	110000101000010000101000010000
MELmytilinidiaceae	110000101100010100010100000010
MELplatystomaceae	110000101000010100010101000000
MELpyrenulaceae	110000100010010100010001000000
MELrequienellaceae	110000101000010000110101000000
MELtrypetheliaceae	110000100010010100010101000000
MELANOMMATALES	110000101110011100111101110010

OPEopegraphaceae	110010000010010000110010000100
OPEroccellaceae	110010000010010000110010000000
OPEGRAPHALES	110010000010010000110010000100

PATpatellariaceae	110010001000011100010110000100

PLEarthopyreniaceae	110001001010001100000101000000
PLEbotryosphaeriaceae	110001001100111100000101000000
PLEcucurbitariaceae	110001001100011100000101000000
PLEdacampiaceae	110001001100111100001001000000
PLEdimeriaceae	110001001001011100011001000000
PLEhysteriaceae	110001001100011110010100000100
PLEleptosphaeriaceae	110001001100011100010101000000
PLElophiostomataceae	110001001100011100010101000000
PLEmicropeltidaceae	110001001000001100001000010000
PLEparodiellaceae	110001000000110101001001000000
PLEphaeosphaeriaceae	110001001100111110000101000000
PLEphaeotrichaceae	110001001000010100010101100000
PLEpleosporaceae	110001001100011011011101100000
PLEpleomassariaceae	110001001100010100010101000000
PLEpolystomellaceae	110001001000110100001100000001
PLEpyrenophoraceae	110001000100110010000101000000
PLEtubeufiaceae	110001000001110010001001000000
PLEventuriaceae	110001001000101010010101000000
PLEOSPORALES	110001001111111111011101110101

6. DATA ANALYSIS

Parsimony analysis was carried out with PAUP version 3.0 (Swofford, 1990) for the MacIntosh computer. The Heuristic algorithm with a general swap option and minimal trees kept was utilized for the 50 species 30 character matrix. Several 10 hour run on an Macintosh IIfx computer generated several thousand trees without fully swapping on all those held. Felsenstein (1978) calculated the number of trees for a 20 taxon matrix to be 8.2 x 10 to the 21st power, indicating that the number for the 50 taxa matrix used in this study would be quite large. The shortest tree found in 10 runs with a 5000 maximum number of trees saved was utilized for the analysis.

The Branch and Bound method with upper bounds computed stepwise and a furtherest additional sequence was used for the 8 ordinal taxa and 30 character matrix. The Bootstrap algorithm (Felsenstein, 1985) with a Branch and Bound search was used to place confidence levels on the 8x30 matrix groups.

The Homoplasy Excess Ratio (Archie, 1989) was calculated on the basis of 100 random trees generated with MacClade and PAUP, for both ordinal data sets.

Character Compatibility Analysis utilized the Macintosh version (Ellis, 1989) of the Clique algorithm from Phylip 3.2 (Felsenstein, 1989).

MacClade 3.0 was utilized with noted cautions to shuffle the character data in the 8x30 matrix for the HER analysis and to obtain tree lengths of trees based on compatible character cliques.

The arguments against the use of consensus trees for classification by Miyamoto (1985) and Carpenter (1988) are noted. I agree with the argument of Anderberg and Tehler (1990) that the perspective of the consensus tree is valid in taxonomic practice and in particular in this study.

7. THE OUTGROUP

The outgroup for all analyses was the Myriangiaceae. The historical ancestral reference for the bitunicate ascomycetes is the Myriangiaceae (Luttrell,1951; Barr 1979). Both fissitunicate and rostrate type asci are found in the taxa assigned to the Myriangiales by Barr (1987).

The parsimony analysis of the ascus character suite suggests a close relationship between the ascus types, and subsequently the taxa which produce them. Thus, the outgroup for the family data matrix is the Myriangiaceae scored for a fissitunicate ascus.

The outgroup for the ordinal data matrix is the summation of characters for the Barr order. The Elsinoeaceae was excluded from the Myriangiaceae outgroup summation because of the distance between the two taxa in the family tree.

8. RESULTS

8.1 The family taxa.

The shortest tree found for both data sets was 119 steps. General trends were made apparent. A progression on the ordinal level occurred from the designated Myriangiaceae outgroup to a mixture of families from the Capnodiales and the Chaetothyriales.

The taxa of Barr's Pleosporales were then derived and the members of the Melanommatales formed groups in the tree's terminus.

The familial taxa did not strictly group in orders as Barr defined them . The Dothideales families were intermixed with all orders except the Capnodiales and the Chaetothyriales. The Dothideales and the Pseudosphaeriaceae and the Dothioriaceae formed clades with families from the Pleosporales and the Elsinoeaceae.

Mixed families clades occurred with a high frequency level in the 5000 retained-tree analyses. These were 1) CAPeuantennariaceae and CHAherpotrichiellaceae; 2) DOTdothioraceae and MYRelsinoaceae with the PLEpyrenophoraceae; 3) PLEhysteriaceae and PATpatellariaceae; 4) OPEopegraphaceae and OPEroccellaceae with the CHAstrigulaceae, MELpyrenulaceae, and the MELtrypetheliaceae; 5) PLEpleosporaceae and DOTpseudosphaeriaceae, PLEventuriaceae, and DOTdothideaceae.

Several regularly occurring clades were formed with high frequency by families of the same BARR order: 1) OPEopegraphaceae and OPErocellaceae; 2) PLEparodiellaceae and PLEtubeufiaceae with PLEpolystomaceae; 3) MELfenestellaceae and MELmassariaceae; 4) PLEphaeotrichaceae and PLEpleomassariaceae.

The general phylogenetic trends reflect a progression in the hamathecial character. The lack of sterile elements or the occurrence of periphysoids is the ancestral state. The cellular pseudoparaphyses character occurs predominately in the next derived clades with the trabecular pseudoparaphyses occurring in the most derived taxa. The paraphysoidal taxa occur on derived clades. The cladistic outlines of Tehler (1988, 1990) with conclusions on hamathecial character transitions could be considered as supportive of this trend. However, the data in Tehler's studies are suspect because of dependence on a "few key characters," some of which have faulty use (i.e. clamp, paraphysoid, bitunicate). I predict that the mycological conclusions from Tehler's (1988) "hypothetical phylogeny" will be unsupported with molecular data (unpublished observations).

The lichenized state occurs in several clades that form a large unresolved node at the clade terminus.

Character Compatibility Analysis yielded identical largest cliques with both data sets: Clique Characters 1,2,3,4,5,6,7,8,23,27,29,30. This clique formed groups from all families into the equivalent of Barr orders on the basis of hamathecial characters. Accordingly, the nonhamathecial Capnodiales, Dothideales and Myriangiales were grouped together.

8.2 The ordinal taxa.

Two characters, 1 and 14, were scored the same for all orders. The periphysoidal Capnodiales data set had 21 phylogenetically significant characters and 7 autapomorphic characters. The Capnodiales without a hamathecium had 22 characters with at least two state changes and 6 characters with a state change in the terminal branch.

Two Trees of different lengths were generated for each data matrix with a different scoring for the periphysoid character in the Capnodiales.

One tree (Fig. 2) of 44 steps was found for Capnodiales scored for the presence of periphysoids. Five trees (Figs. 2-6) of 45 steps were found for a Capnodiales without a hamathecium.

The outer frame of the tree topology was the same for all trees; the outgroup, Myriangiales and the Opegraphales and the Patellariales forming a sibling pair clade. The clade formed of the remaining orders, the Capnodiales, Chaetothyriales, Pleosporales, Melanommatales and the Dothideales, had three topology patterns (Figs. 2, 4, and 3,5,6).

The relationship of the Capnodiales to the Chaetothyriales was closest in Figs. 2 and 4 topologies. The Dothideales formed a sibling taxon to the paired Melanommatales and Pleosporales in the trees of Fig. 2 and 4, to the Chaetothyriales, Melanommatales and Plesporales in trees of Figs. 3 and 5, and subtends all four of these orders in Fig. 6.

The Homoplasy Estimate Ratio (Archie, 1989) was 0.1898 for the 44 length tree and 0.1399 for the 45 length trees.

An acceptable confidence level for tree branches generated with Bootstrap is 95. In all nonhamathecial Capnodiales trees the Opegraphiales and the Patellariales were scored 63 and the large clade for the Capnodiales, Chaetothyriales, Dothideales, Melanommatales and Pleosporales was scored 61. The Pleosporales and the Melanommatales were scored 50 where the two orders were sibling taxa.

Character compatibility analysis generated a largest clique of 18 characters: 1,2,3,4,5,6,7,9,10,14,21,23,24, 25,26,27,29,30. The characters of this clique were congruent with the characters with a homoplasy ratio of 1.0 in the identical periphysoidal and the nonhamathecial trees (Fig. 2).

9. DISCUSSION

A major contemporary problem in the systematics of the ascostromatic ascomycetes is the need to recognize robust monophyletic groups. A phylogenetic cladistic approach would lead to the proposal of a classification of the ascostromatic ascomycetes that is based on the phylogeny of taxa related through shared derived characters (Scott-Ram, 1990).

9.1 Redefinition of the Loculoascomycetes.

The classification of the ascostromatic ascomycetes as the taxon Loculoascomycetes is brought into question with the recognition of several ascostromatic ascus types. The original definition by Luttrell (1955) was: Loculoascomycetes. *Ascis bitunicatis, in ascostromatae evolutis.* A single type of ascus in an ascostroma definition is void with the recognition that the bitunicate ascus is comprised of two types of asci, the rostrate and the fissitunicate. Two other ascus types, the extenditunicate and the *Meliola* ascus, also occur in ascostromatic ascomycetes.

Two emended definitions of the Loculoascomycetes are apparent as a way to retain the name for a taxon.

1). *Ascis* with postmeiotic stretching of wall, *in ascostromatae evolutis.* This broad definition would allow incorporation of ascomycetes with a modified meiosporangium formed in the ascostroma into a single taxon. The implication is for a monophyletic group.

2). *Ascis* fissitunicate, *in ascostromatae evolutis.* This emended definition would provide for one of three groups of ascostromatic ascomycetes. The taxonomic level implied is supraordinal. Two or more equally ranked taxa would have to be created for the two other ascostromatic ascomycetes, as well as for other ascomycetous clades.

3) The most sweeping proposition is to abandon the use of Loculoascomycetes altogether as a supraordinal taxon for ascostromatic fungi. Thus the term loculoascomycetes would be relegated to "weed" status along with phycomycetes and ascomycetes.

9.2 A phylogeny of the fissitunicate ascostromatic ascomycetes.

The use of ascus characters provides a hypothetical basis for recognition of three monophyletic groups of ascostromatic ascomycetes. The largest of these, those with the fissitunicate ascus, forms clades at the familial level which conflict with the ordinal groups delimited by Barr. The ordinal trees also reflect an unstable classification of the fissitunicate fungi.

The use of 30 characters to group 50 taxa guarantees unresolved nodes in the tree. The inability to produce a complete examination of all trees generated with a reasonably long computer run with the PAUP algorithm supports the high degree of homoplasy. The Consistency Index of

The classifications of Luttrell and Barr give relatively heavy intuitive weights to hamathecial characters in the definitions of orders. The remaining characters of habit, habitat, nutrition, conidiogeny, and ascospore symmetry are used within each of their ordinal groups recognized from the weighted characters.

The unweighted hamathecial characters results in a more parsimonious determination of relationships. The family tree indicates the hamathecial characters as having varied value as a monophyletic group predictor rather than as a weighted character intended to predict ordinal groups.

Two groups of fissitunicate ascomycetes can be recognized from the family tree. One group is formed by families with no hamathecium or with periphysoids: the Myriangiaceae, the Cookellaceae, the Microthyriaceae, and the Capnodiales and the Chaetothyriales with one exception. A second group is formed by the families with pseudoparaphyses and paraphyses: Pleosporales, Melanommatales, Opegraphiales, Patellariales, the Elsinoeaceae, the Strigulaceae and the Dothideales. The nonhamathecium/ periphysoid group is ancestral to other fissitunicate ascomycetes.

Janex-Favre (1988) maintained that the appearance of pseudoparaphysis variants such as the periphysoids and trabeculae in the mature ascocarp are not good taxonomic characters. She argued that the origin and development of the sterile elements is the only basis for comparison of species. Additionally, the Verrucariaceae ascocarp development was used to demonstrate placement in the ascohymeniales or the ascoloculareles is difficult on the basis of sterile element ontogeny.

The examples at hand are the issue of periphysoids in the Capnodiaceae and the recognition of pseudoparaphyses in the Dothideales. The presence of periphysoids was used to distinguish the Chaetothyriales from the Capnodiales by Barr (1987). This classification ignored an account of the type species of the genus *Capnodium* , *C . salicinum* , that found periphysoids (Reynolds, 1978). Subsequent examination of *Capnodium* specimens provided by O. Eriksson from Herbarium S in Stockholm showed variability in the presence of periphysoids (personal observation). The conclusion is that the periphysoids were retained in some specimens or species and not in others.

The use of two alternate data sets for phylogenetic analysis supports the presence of periphysoids in the Capnodiales. The topology of the trees generated with families of Barr's Capnodiales having periphysoids in one data set and not being scored for them in another was identical.

This observation was supported at the ordinal level. The alternate data sets of Capnodiales with and without periphysoid scoring provided identical largest-cliques with Character Compatibility analysis. Identical trees were produced in the parsimony analysis for the periphysoidal Capnodiales and Tree 1 of the nonhamathecial order.

The occurrence of dothideaceous families in clades with families from the Melanommatales, the Pleosporales suggests that the phylogenetic significance of a sterile element in the centrum is indeed hard to interpret from morphological or developmental observations.

The Dothideales families characterized without a hamathecium are shown as more related to other ordinal groups with a hamathecial character than to each other in the order to which they are assigned.

The six families of the order are members of three clades. Only one clade consists solely of Dothideales families; it is joined to the tree at an unresolved node along with clades formed by the Melanommatales and the Opegraphiales. The other two clades are formed with families of the Pleosporales and a single member of the Myriangiales, the Elsinoeaceae.

A second explanation for the distribution of dothidaceous families is the loss of the hamathecial character in some point of development and at several times in the evolution of the related taxa.

There is a discrepancy between the definitions of the pseudoparaphysis. Luttrell (1965) clarified the terms paraphysoids and pseudoparaphyses as sterile elements that are distinct from remnants of interascal centrum tissue. Barr (1979) emphasized appearance rather than origin. Terms were based on Chester's (1938) and Groenhart's (1965a,b) concepts. Cellular pseudoparaphysis was characterized as an internal pseudoparaphysis formed by stretching and intercallary growth from top to bottom of the ascocarp locule. Eriksson (1981) used pseudoparaphysis in the sense of Luttrell and paraphysoid as equivalent to the trabecular pseudoparaphyses and originating as stretched centrum tissue.

The Barr families scored for trabecular pseudoparaphyses (Character 6) occupy a definite zone in the family tree. The Pleosporales taxa scored for the cellular pseudoparaphyses form branches at three nodes; two most ancestral of these branches are terminated by single taxa and the next derived clade is formed by three families. A subsequent unresolved node is formed from a clade with a complex branching pattern of families from the Pleosporales and the Dothideales and the Elsinoeaceae and a single taxon clade. Seven Pleosporaceae families form 2 single taxon branches and three branches of paired taxa at the next derived node, one a sibling pair with the Patellariaceae.

The Barr families scored for cellular pseudoparaphyses (Character 7) occur in the uppermost reaches of the tree. The Melanommatales families all occur in the terminal unresolved node. Seven clades are formed by Melanommatales families; one clade is formed from two families and the Opegraphiales.

The "concensus taxonomy" (Reynolds, 1989) of the periodically revised "Outline of the Ascomycetes" was criticized for its seeming arbitrary taxonomic assessments; the family synonomies in a recent version (Eriksson and Hawksworth, 1990) can be measured against the results presented in Fig. 1. The merger of the Pseudosphaeriaceae and the Pleosporaceae is feasible because of their relatively high frequence (85%) as sibling taxa. The merger of near neighbors Trichopeltinaceae with the Microthyriaceae is less justified. Other synonomies proposed that are not supported by the family tree include the Acrocordiaceae and the Requinellaceae with the Pyrenulaceae, the Kriegeriellaceae with the Pleosporaceae, and the Platystomaceae with the Lophiostomataceae.

The ordinal tree topologies are somewhat supportive of the observations drawn from the family tree, despite the constraint of the weighed hamathecial character implicit with the use of the Barr defined groups. The confidence levels for taxa groups and for homoplasy were indicative of the poor quality of results from morphological character data.

The one of five trees of 45 length for the nonhamathecial Capnodiales tree that was identical for the 44 length tree periphysoidal tree differed only in the number of steps required for Character 8 (2 for the periphysoidal and 3 for the nonhamathecial). This observations suggests that the presence or absence of periphysoids in the Capnodiaceae is insignificant as a character to separate the two Barr orders.

The Homoplasy Estimate Ratio (Archie, 1989) was low indicating little phylogenetic content in the trees. The HER for the 44 length periphysoidal Capnodiales was a very low 1898, and was only 0.499 higher than the 45 length Barr defined nonhamathecial Capnodiales.

The low confidence levels obtained with Bootstrap analysis indicate that the little phylogenetic significance can in reality be placed in the trees generated with both the periphysoid and the nonhamathecial Capnodiales.

10. CONCLUSIONS AND RECOMMENDATIONS

1. The Loculoascomycetes as originally defined should be abandoned. The bitunicate ascus is based on two ascus types. Other ascus types occur in the ascostroma. A redefinition *sensu lato* would be inclusive of all ascostromatic ascus types; a *sensu stricto* definition would be applied only to ascostromatic fungi with a fissitunicate ascus. A natural classification based on unorthodox groupings (from a morphological character point of view) could likely require that the name be discarded.

2. The Dothideales sensu Barr is a polyphyletic group.

3. The distinction between Barr's Capnodiales and Chaetothyriales is not justified on the basis of the presence or absence of periphysoids. The merger into the Capnodiales, excluding the Strigulaceae, is a feasible solution.

4. All ascostromatic ascomycetes with hymenial fissitunicate asci are associated in an ascocarp with sterile elements. The development of the hamathecial character as well as its appearance at maturity should be taken into account in morphological characterizations.

5. The hamathecial characters are imprecise indicators of monophyletic groups and their affinities.

6. Morphological characters alone are inadequate for the discovery of monophyletic groups. Contemporary molecular technology provides an alternative data source for the generation of phylogenetic estimates from genetic data (Hillis and Moritz, 1990). A commingling of morphological and molecular data and the pursuant analyses should provide needed insight leading to an improved classification.

11. LITERATURE CITED

Anderberg, A. and A. Tehler. 1990. Consensus trees, a necessity in taxonomic practice. Cladistics 6:399-402.

Archie, J. W. 1989. Homoplasy excess ratios: new indices for measuring levels of homoplasy in phylogenetic systematics and a critique of the consistency index. Syst. Zool. 38:253-269.

Arx, J. A. von and E. Müller. 1975. A re-evaluation of the bitunicate ascomycetes with keys to families and genera. CBS Studies in Mycology No. 9. Baarn.

Barr, M. E. 1979. A classification of Loculoascomycetes. Mycologia 71:935-957.

Barr, M. E. 1987. Prodromus to Class Loculoascomycetes. Privately published by the author.

Carpenter, J. M. 1988. Choosing among multiple equally parsimonious cladograms. Cladistics 4:291-296.

Chesters, C. G. C. 1938. Studies on British pyrenomycetes. II: A comparative study of Melanomma pulvis-pyrius (Pers.) Fuckel, Melanomma fuscidulum Sacc. and Thyridaria rubro-notata (B. & Br.) Sacc. Trans. Brit. Mycol. Soc. 22:116-150.

Ellis, W. N. 1989. Macintose version of Phylip 3.2. Institute of Zoology. Amsterdam, The Netherlands.

Eriksson, O. 1981. The families of bitunicate ascomycetes. Opera Bot. 60:1-220.

Eriksson, O. and D. L. Hawksworth. 1990. Outline of the Ascomycetes - 1989. Systema Ascomycetum 8:119-318.

Felsenstein, J. 1978 The number of evolutionary trees. Syst. Zool. 27:27-33.

Felsenstein, J. 1985. Confidence limits on phylogenies: an apprasial using the bootstrap. Evolution 39:783-791.

Felsenstein, J. 1989. Phylip 3.2 manual. University of California Herbarium, Berkeley, California.

Gabel, A. W. and L. H. Tiffany. 1987. Host-parasite relations and development of Elsinoe panici. Mycologia 79:737-744.

Gelfand, D. H. and T. J. White. Thermostable DNA polymerases. 1990. pages 129-141. in Innis, M. A., D. H. Gelfand, J. J. Sninsky, T. J. White (editors). Academic Press. New York.

Groenhart, P. 1965a. Studies in ascostromatic lichen-fungi. I. The problems of Ascohymeniales and Ascoloculares. Persoonia 4:1-7.

Groenhart, P. 1965b. Studies in ascostromatic lichen-fungi. II. Types of ascostromata. Persoonia 4:9-13.

Hawksworth, D. L., B. C. Sutton, and G. C. Ainsworth. 1983. Ainsworth and Bisby's dictionary of the fungi (including the lichens), 7th ed. Commonwealth Mycological Institute, Kew, Surrey, England.

Janex-Favre, M. C. Étude ontogénique et structurale des périthèces du Dictyotrichiella semiimmersa Candoussau et Sulmont (Pyrénomycètes, Herpotrichiellaceae). Cryptogamie, Mycol. 9:133-151.

Luttrell, E. S. 1951. Taxonomy of the Pyrenomycetes. Univ. Missouri Studies Sci. Ser. 24:3):1-120.

Luttrell, E. S. 1955. The ascostromatic ascomycetes. Mycologia 47:511-532.

Luttrell, E. S. 1965. Periphyses, paraphyses and pleudoparaphyses. Trans. Brit. Mycol. Soc. 48:135-144.

Luttrell, E. S. 1989. Morphology of Meliola floridensis. Mycologia 81:192-204.

Miyamoto, M. M. 1985. Copnsensus cladograms and general classifications. Cladistics 1:186-189.

Nannfeldt, J. A. 1932. Studien uber die Morphologie und Systematik der nichtlichenisierten inoperculaten Discomyceten. Nova Acta R. Soc. Scient. Upsal. Ser. IV, 8:1-368, pls. 1-20.

Reynolds, D. R. 1971. The wall structure of a bitunciate ascus. Planta 98:244-257.

Reynolds, D. R. 1979. Capnodium salicinum Montagne emend. Mycotaxon 26:179-193.

Reynolds, D. R. 1981a. Ascomycete systematics: The Luttrellian Concept. Springer-Verlag. New York.

Reynolds, D. R. 1987. A nonbitunicate ascus in the ascostromatic genus Asterina. Cryptogamie, Mycol. 8:251-268.

Reynolds, D. R. 1989a. An extendituncate ascus in the ascostromatic genus Meliolina. Cryptogamie, Mycol. 10:305-320.

Reynolds, D. R. 1989b. The bitunicate ascus paradigm. The Botanical Rev. 55:1-52.

Scott-Ram, N. R. 1990. Transformed cladistics, taxonomy, and evolution. Cambridge University Press. New York.

Swofford, D. L. 1990. PAUP: Phylogenetic analysis using parsimony. Version 3.0. Illinois Natural History Survey. Champaign, Illinois.

Tehler, A. 1988. A cladistic outline of the Eumycota. Cladistics 4:227-277.

Tehler, A. 1988. A cladistic outline of the Eumycota. Cladistics 4:227-277.

Tehler, A. 1990a. A new approach to the phylogeny of Euasomycetes with a cladistic outline of Arthoniales focussing on Roccellaceae. Can. J. Bot. 68: 2458-2492.

12. FIGURES

FIGURE 1. Cladogram of fissitunicate ascostromatic families as defined by Barr (1987). The family trees for two data sets differing in the scoring of the Capnodiales for periphysoids and for nonhamathecial are identical. The family taxon is prefixed with a capitalized abbreviation of the order name: CAP=Capnodiales; CHA =Chaetothyriales; DOT =Dothideales; MEL=Melanommatales; MYR = Myriangiales; OPE = Opegraphiales; PAT=Patellariales; PLE=Pleosporales. The Bootstrap values are indicated in internodes. This consensus tree is from 5000 trees of 119 steps.

FIGURES 2-6. Cladograms of fissitunicate ascostromatic orders. The taxa are those defined by Barr (1987); the characterization is a summary of the Barr family characters with the exception of the Myriangiales, which is based on the Myriangiaceae and the Cookellaceae. The cladograms were generated with the PAUP algorithm. The internode numbers are Bootstrap values.

FIGURE 2. This cladogram was the same for two data sets with different scoring for the Capnodiales; they differ in Bootstrap values for all but one of the groups. The bracketed number of the pair indicates the value for the data matrix with the periphysoid character of Reynolds (1979); the other, unbracketed number is the value for matrix with the nonhamathecial character of Barr (1987) or for the same value for both data sets.

FIGURES 3-6. Five trees were discovered for the nonhamathecial Capnodiales. Figure 3 is the consensus tree and an identical tree of the five; The internode numbers are the boot strap values.

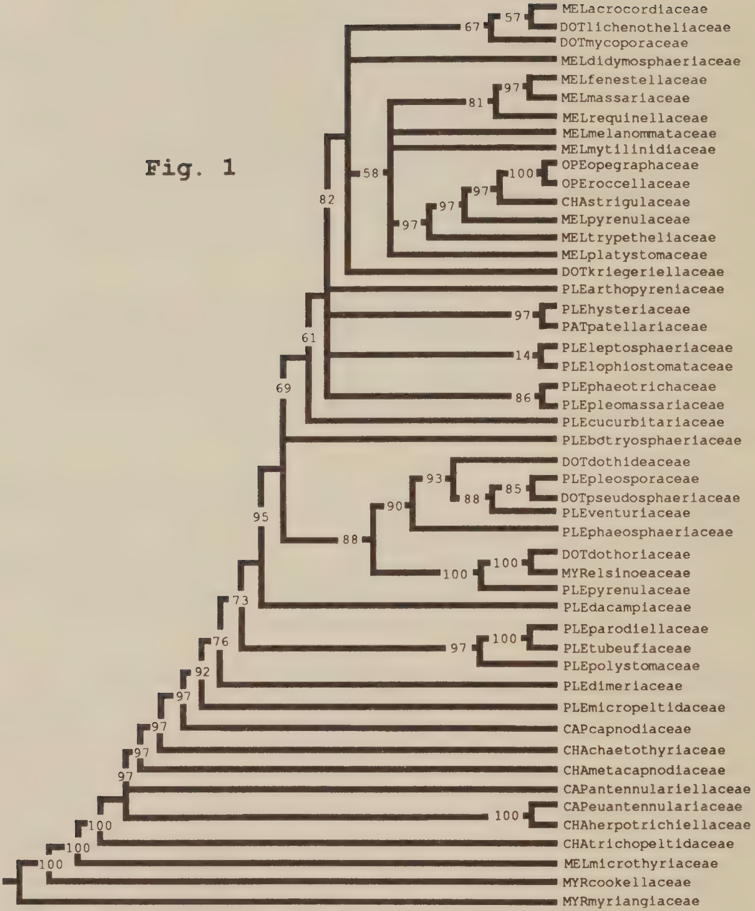

MELacrocordiaceae
DOTlichenotheliaceae
DOTmycoporaceae
MELdidymosphaeriaceae
MELfenestellaceae
MELmassariaceae
MELrequinellaceae
MELmelanommataceae
MELmytilinidiaceae
OPEopegraphaceae
OPEroccellaceae
CHAstrigulaceae
MELpyrenulaceae
MELtrypetheliaceae
MELplatystomaceae
DOTkriegeriellaceae
PLEarthopyreniaceae
PLEhysteriaceae
PATpatellariaceae
PLEleptosphaeriaceae
PLElophiostomataceae
PLEphaeotrichaceae
PLEpleomassariaceae
PLEcucurbitariaceae
PLEbotryosphaeriaceae
DOTdothideaceae
PLEpleosporaceae
DOTpseudosphaeriaceae
PLEventuriaceae
PLEphaeosphaeriaceae
DOTdothoriaceae
MYRelsinoeaceae
PLEpyrenulaceae
PLEdacampiaceae
PLEparodiellaceae
PLEtubeufiaceae
PLEpolystomaceae
PLEdimeriaceae
PLEmicropeltidaceae
CAPcapnodiaceae
CHAchaetothyriaceae
CHAmetacapnodiaceae
CAPantennulariellaceae
CAPeuantennulariaceae
CHAherpotrichiellaceae
CHAtrichopeltidaceae
MELmicrothyriaceae
MYRcookellaceae
MYRmyriangiaceae
57
67
97
81
58
82
100
97
97
97
61
97
14
69
86
93
85
90
88
95
88
100
100
73
100
76
97
92
97
97
97
97
100
100
100
100

Fig. 1

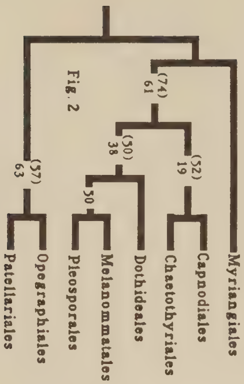


Fig. 2
Myriangiales
Capnodiales
Chaetothyriales
Dothideales
Melanommatales
Pleosporales
Opegraphiales
Patellariales
(74) 61
(50) 38
(52) 19
50
(57) 63

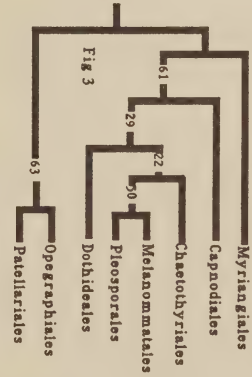


Fig 3
Myriangiales
Capnodiales
Chaetothyriales
Melanommatales
Pleosporales
Dothideales
Opegraphiales
Patellariales
61
29
22
50
63

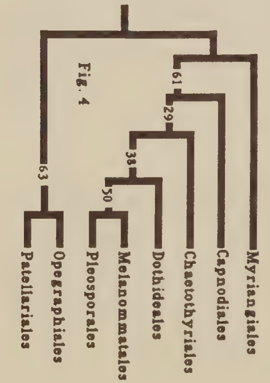


Fig. 4
Myriangiales
Capnodiales
Chaetothyriales
Dothideales
Melanommatales
Pleosporales
Opegraphiales
Patellariales
61
29
38
50
63

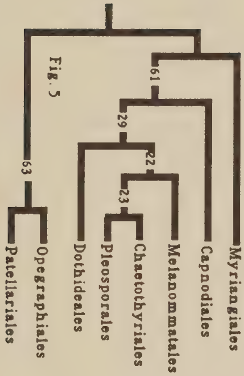


Fig. 5
Myriangiales
Capnodiales
Melanommatales
Chaetothyriales
Pleosporales
Dothideales
Opegraphiales
Patellariales
61
29
22
23
63

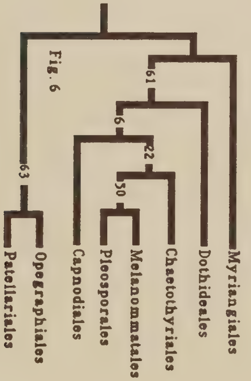


Fig. 6
Myriangiales
Dothideales
Chaetothyriales
Melanommatales
Pleosporales
Capnodiales
Opegraphiales
Patellariales
61
6
22
50
63

MYCOTAXON

Volume XLII, pp. 125-147 October-December 1991

MELIOLACEAE OF SOUTH INDIA - X

V.B. Hosagoudar
Botanical Survey of India, Southern Circle, Coimbatore
651003 India

and

R.D. Goos
Department of Botany, University of Rhode Island
Kingston, RI 02881

ABSTRACT

The paper gives an account of 41 species and infra-specific taxa of the Meliolaceae collected from the Anamalai range of southern India, including two species from Karnataka. Of these, *Asteridiella acronychiae-pedunculatae*, *A. anamalaiana*, *Irenopsis xanthophylli*, *Meliola altissimae*, *M. bhesae*, *M. ceropegiae*, *M. gamblei*, *M. travancoricae*, and *M. trewiae* are new species; *Meliola banosensis* Sydow var. *puereriae*, *M. connari* Yates var. *indica*, *M. memecylicola* Hansf. var. *indica*, *M. pulchella* Speg. var. *syzygii*, and *M. teramni* Sydow var. *milletiae* are new varieties; *Asteridiella malloticola* (Yamam.) Hansf., *Irenopsis thespesiae* Hansf., *Meliola artocarpi* Yates and *M. parvuta* Sydow are reported for the first time from India. The remaining species are first reports after the type collections, are reported for the first time from the state of Tamil Nadu, or are new host records.

Key Words: Meliolaceae, Black Mildews, *Asteridiella* *Irenopsis*, *Meliola*, India.

This paper gives an account of 41 species and infra-specific taxa of the Meliocaceae collected from the Anamalai range of southern India, including two species from Karnataka. Eight new species and five new varieties are recognized. We are using the term phialide in place of mucronate hyphopodium, based on recent studies of Mueller _et_ _al_. (1991).

1. **Amazonia peregrina** Sydow, Ann. Mycol. 15: 238, 1917.
On leaves of _Maesa_ _indica_ (Roxb.) DC. (Myrsinaceae), near Sholayar dam, Valparai, Coimbatore, Dec. 25, 1990, V.B. Hosagoudar HCIO 30513.

2. **Amazonia syzygii** Hosagoudar in Hosagoudar & Goos, Mycotaxon 36: 236, 1989.

On leaves of _Syzygium_ _cumini_ (L.) Skeels (Myrtaceae), Shankarankudi, Valparai, Coimbatore, Dec. 27, 1990., V.B. Hosagoudar HCIO 30514

3. **Asteridiella acronychiae-pedunculatae** Hosagoudar, sp. nov. (Fig. 1)
Plagulae amphigenae, densae, crustosae, ad 2 mm diam., raro confluentes. Hyphae rectae vel subrectae, alternatae vel oppositae acuteque ramosae, laxe reticulatae, cellulis 27-34 x 7-9.5 µm. Hyphopodia capitata alternata, recta vel leniter curvula, antrorsa vel subantrorsa, 27-40.5 µm longa; cellula basali cylindracea vel cuneata, 9-18.5 µm longa; cellula apicali clavata, ovata, cylindracea, integra vel angulosa, 18-21.5 x 12-15.5 µm. Phialis numerosa, illis hyphopodia capitatis commixta, alternata vel opposita, ampullacea, 24-31 x 9-12.5 µm. Perithecia dispersa, ad 115 µm; cellulae peritheciales conoideae vel mammelliformiae, ad 18.5 um longae; ascosporae obovoideae, 4-septatae, constrictae, 34-37.5 x 15-21.5 µm.

Colonies amphigenous, dense, crustose, up to 2 mm in diameter, rarely confluent. Hyphae straight to substraight, branching alternate to opposite at acute angles, loosely reticulate, cells 27-34 x 7-9.5 µm. Capitate hyphopodia alternate, straight to slightly curved, antrorse to subantrorse, 27-40.5 µm long; stalk cells cylindrical to cuneate, 9-18.5 µm longa; head cells clavate, ovate, cylindrical, entire to angular, 18-21.5 x 12-15.5 µm. Phialides numerous, mixed with capitate hyphopodia, alternate to opposite, ampulliform, 24-31 x 9-12.5 µm. Perithecia scattered, up to 115 µm; perithecial cells conoid to mammelliform, up to 18.5 µm long; ascospores obovoidal, 4-septate, constricted, 34-37.5 x 15-21.5 µm.

Holotype: On leaves of _Acronychia_ _pedunculata_ (L.)

Miq. (Rutaceae), Erameparai, Top slip, Coimbatore, Dec. 20, 1990, V.B. Hosagoudar HCIO 30515.

Asteridiella acronychiae Hu has been reported on A. pedunculata from China (Hu & Lu, 1986). The new species differs from it in having smaller capitate hyphopodia, perithecia and ascospores.

4. **Asteridiella anamalaiana** Hosagoudar, sp. nov. (Fig. 2).

Plagulae epiphyllae, densae, dispersae, crustosae, velutinae, ad 2 mm diam. Hyphae subrectae vel anfractuosae, oppositae vel irregulariter acuteque ramosae, laxe vel densae reticulatae, cellulis 24-28 x 6-8 µm. Hyphopodia capitata alternata, minusve 1% opposita, plerumque antrorsa, 21-28 µm longa; cellula basali cuneata vel cylindracea, 6-9.5 µm longa; cellula apicali globosa, angulosa vel raro sublobata, 15-18 x 18-22 µm. Phialis numerosa, illis hyphopodia capitatis commixta, opposita vel alternata, ampullacea, 18-22 x 6-9.5 µm. Perithecia dispersa, globosa, ad 140 um; cellulae peritheciales protrudae, conoideae, curvatae ad apicem, 12-15.5 µm longae; ascosporae obovoideae vel cylindraceae, 4-septatae, leniter constrictae, 43-53 x 18-22 µm.

Colonies epiphyllous, scattered, dense, crustose to velvety, up to 2 mm in diameter. Hyphae substraight to crooked, branching opposite to irregular at acute angles, loosely to closely reticulate, cells 24-28 x 6-8 µm. Capitate hyphopodia alternate, mostly antrorse, 21-28 µm long; stalk cells cylindrical to cuneate, 6-9.5 µm long; head cells globose, angular to rarely sublobate, 15-18 x 18 - 22 µm. Phialides numerous, mixed with capitate hyphopodia, opposite to alternate, ampulliform, 18-22 x 6-9.5 µm. Perithecia scattered, globose, up to 140 um, perithecial cells protruded, conoid, curved at the apex, 12-15.5 µm long; ascospores obovoidal to cylindrical, 4-septate, slightly constricted, 43-53 x 18-22 µm.

Holotype: On leaves of Sterculia urens Roxb. (Sterculiaceae), Nedungundru, Velonie, Valparai, Coimbatore, Dec. 23, 1990, V.B. Hosagoudar HCIO 30529 (as Meliola anamalaiana)

This species is close to Asteridiella buettneriae (Stevenson) Hansf., reported on Buettneria ramosissima from Brazil (Hansford, 1961), but differs from it in having crustose and only epiphyllous colonies, smaller perithecia and larger ascospores.

5. **Asteridiella cyclopoda** (Stev.) Hansf., Sydowia 10: 47, 1957.

On leaves of Vernonia monosis Clarke (Asteraceae), Shankarankudi, Valparai, Coimbatore, Dec. 12, 1990, V.B. Hosagoudar HCIO 30516.

6. **Asteridiella formosensis** (Yamam.) Hansf., Sydowia 10: 48, 1957.

On leaves of *Callicarpa tomentosa* (L.) Murray (Verbenaceae), Kozhikamathi, Top slip, Coimbatore, Dec. 21, 1990, V.B. Hosagoudar HCIO 30517.

7. **Asteridiella malloticola** (Yamam.) Hansf. Sydowia 10: 49, 1957.

On leaves of *Mallotus philippensis* (Lam.) Muell.-Arg. (Euphorbiaceae), Nedungundru, Velonie, Valparai, Coimbatore, Dec. 23, 1990, V.B. Hosagoudar HCIO 30518.

8. **Asteridiella viveknanthanii** Hosagoudar, Sydowia 40: 114, 1987.

On leaves of *Clerodendrum viscosum* Vent. (Verbenaceae), Sheikalmudy, Valparai, Coimbatore, Dec. 23, 1990, V.B. Hosagoudar HCIO 30519.

9. **Irenopsis benguetensis** Stev. & Rold. ex Hansf., Sydowia 26: 311, 1963.

On leaves of *Ficus exasperata* Vahl (Moraceae), near Sholayar dam, Valparai, Coimbotore, Dec. 29, 1990, V.B. Hosagoudar HCIO 30520. On leaves of *F. tinctoria* Forst. f. ssp. *gibbosa* (Blumea) Corner var. *cuspidifera* (Miq.) Chithra (Moraceae), Nedungundru, Velonie, Valparai, Coimbatore, Dec. 23, 1990, V.B. Hosagoudar HCIO 30521.

10. **Irenopsis thespesiae** Hansf., Reinwardtia 3: 91, 1954.

On leaves of *Thespesia lampas* (Cav.) Dalz. ex Dalz. & Gibs. (Malvaceae), Koomati, Valparai, Coimbatore, Dec. 26, 1990, V.B. Hosagoudar HCIO 30523.

11. **Irenopsis triumfettae** (Stev.) Hansf. & Deight., CMI Mycol. Pap. 23: 14, 1948.

On leaves of *Triumfetta rhomboidea* Jacq. (Tiliaceae), near Sholayar dam, Valparai, Coimbatore, Dec. 25, 1990, V.B. Hosagoudar HCIO 30524, 30525.

12. **Irenopsis xanthophylli** Hosagoudar, sp. nov. (Fig. 3)

Plagulae epiphyllae, densae, crustosae, ad 3 mm diam. Hyphae rectae, subrectae vel leniter anfractuae, oppositae acuteque vel laxe ramosae, laxe vel densae reticulatae, cellulis 18-25 x 6-9.5 µm. Hyphopodia capitata alternata, antrorsa vel subantrorsa, recta vel curvula, 21-31 µm longa; cellula basali cylindracea vel cuneata, 6-12.5 µm longa; cellula apicali globosa, ovata, integra vel angulosa vel irregulariter sublobata, 15-18.5 x 14-18 µm. Phialis illis hyphopodia capitatis commixta, opposita vel alternata, ampullacea, 15-21 x 9-12.5 µm.

Perithecia dispersa, globosa, ad 155 µm; setae peritheciales 10-12, rectae, nigrae, leniter flexuosae ad apicale portionae, obtusae, ad 155 µm longae; cellula peritheciales protruda, conoidea, ad 12 µm longa; ascosporae obovoideae, 4-septatae, leniter constrictae, 34-43.5 x 12-18.5 µm.

Colonies epiphyllous, dense, crustose, up to 3 mm in diam. Hyphae straight, substraight to slightly crooked, branching mostly opposite at acute to wide angles, loosely to closely reticulate, cells 18-25 x 6-9.5 µm. Capitate hyphopodia alternate, antrorse to subantrorse, straight to curved, 21-31 µm long; stalk cells cylindrical to cuneate, 6-12.5 µm long; head cells globose, ovate, entire to irregularly sublobate, 15-18.5 x 14-18 µm. Phialides mixed with capitate hyphopodia, opposite to alternate, ampulliform, 15-21 x 9-12.5 µm. Perithecia scattered, globose, up to 155 µm; perithecial setae 10-12, straight, black, slightly flexuous at the apical protion, obtuse, up to 155 µm long; perithecial cells protruding, conoid, up to 12 µm long; ascospores obovoidal, 4-septate, slightly constricted at the septa, 34-43.5 x 12-18.5 µm.

Holotype: On leaves of Xanthophyllum flavescens Roxb. (Xanthophyllaceae), Koomati, Valparai, Coimbatore, Dec. 26, 1990, V.B. Hosagoudar HCIO 30526.

There is no prior report of any meliolaceous fungus occurring on members of the Xanthophyllaceae (Hansford, 1961, Katumoto & Hosagoudar, 1989).

13. **Meliola alstoniae** Koord., Verhandl. K. Akad. Wetnsch Amsterdam 13: 170, 1907.

On leaves of Alstonia scholaris (L.) R. Br. (Apocynaceae), Sundarankudi, Valparai, Coimbatore, Dec. 28, 1990, V.B. Hosagoudar HCIO 30527.

Colonies of the fungus were epiphyllous, producing leaf spots.

14. **Meliola altissimae** Hosagoudar sp. nov. (Fig. 4).

Plagulae caulicolae, epiphyllae, densae, ad 2 mm in diam., confluentes. Hyphae rectae vel leniter flexuosae, plerumque oppositae acuteque ramosae, laxe reticulatae, cellulis 34-40.5 x 6-8 µm. Hyphopodia capitata alternata, antrorsa, recta vel curvula, 15-18.5 µm longa; cellula basali cylindracea vel cuneata, 3-6 µm longa; cellula apicali ovata, globosa, piriformia, integra, 9-12.5 x 12-15.5 µm. Phialis illis hyphopodia capitatis commixta, alternata vel opposita, ampullacea, 18-25 x 6-8 µm. Setae myceliales circa perithecia aggregatae, simplices, rectae, obtusae ad apicem, ad 360 µm longae. Perithecia dispersa, ad 124 µm; ascosporae obovoidae, 4-septatae, leniter constrictae, 31-34 x 12-14 µm.

Colonies caulicolous, epiphyllous, dense, up to 2 mm in diameter, often confluent and covering the entire adaxial leaf surface. Hyphae straight to slightly flexuous, branching mostly opposite at acute angles, loosely reticulate, cells 34-40.5 x 6-8 µm. Capitate hyphopodia alternate, antrorse, straight to curved, 15-18.5 µm long; stalk cells cylindrical to cuneate, 3-6 µm long; head cells ovate, globose, pyriform, entire, 9-12.5 x 12-15.5 µm. Phialides mixed with capitate hyphopodia, alternate to opposite, ampulliform, 18-25 x 6-8 µm. Mycelial setae mostly grouped around perithecia, simple, straight, obtuse at the apex, up to 360 µm long. Perithecia scattered, up to 124 µm; ascospores obovoidal, 4-septate, slightly constricted at the septa, 31-34 x 12-14 µm.

Holotype: On leaves and petioles of Vitex altissima L. (Verbenaceae), Koomati, Valparai, Coimbatore, Dec. 26, 1990, V.B. Hosagoudar HCIO 30528.

The new species is close to Meliola viticicola Hansf., M. cookeana Speg. and M. cantareirensis Hansf., but differs from them in having epiphyllous and calulicolous, dense, and widely confluent colonies, substraight to flexuous mycelia, and phialides mixed with capitate hyphopodia.

15. **Meliola artocarpi** Yates, Philipp. J. Sci. 12: 362, 1917.

On leaves of Artocarpus heterophyllus Lam. (Moraceae), Sundarankudi, Valparai, Coimbatore, Dec. 25, 1990, V.B. Hosagoudar HCIO 30530.

16. **Meliola banosensis** Sydow var. **puerariae** Hosagoudar, var. nov. (Fig. 5).

Differt a var. banosensis phialis illis hyphopodia capitatis commixta.

Colonies epiphyllous, thin to subdense, up to 2 mm in diameter, widely confluent. Hyphae straight, substraight to slightly crooked, branching at acute to wide angles, loosely reticulate, cells 21-25 x 6-8.5 µm. Capitate hyphopodia alternate, antrorse to subantrorse, straight to curved, 12-15.5 µm long; stalk cells cylindrical to cuneate, 3-5 µm long; head cells ovate, globose, straight to curved, entire, 9-11 x 9-12.5 µm. Phialides mixed with capitate hyphopodia, alternate to opposite, ampulliform, 15-18.5 x 10-12.5 µm. Mycelial setae few, grouped around perithecia, straight to curved but not uncinate, simple, acute, up to 300 µm long. Perithecia loosely grouped, globose, up to 300 µm; ascospores obovoidal to cylindrical, 4-septate, slightly constricted, 31-37.5 x 9-12.5 µm.

Holotype: On leaves of Puereria sp. (Fabaceae), Erameparai, Top slip, Coimbatore, Dec. 20, 1990, V.B. Hosagoudar HCIO 30531.

Meliola banosensis Sydow has been reported on this host genus from the Philippines (Hansford, 1961). The new variety differs from the var. banosensis in having the Phialides mixed with the capitate hyphopodia.

17. **Meliola bhesae** Hosagoudar, sp. nov. (Fig. 6)

Plagulae epiphyllae, raro amphigenae, densae, ad 4 mm diam., confluentes. Hyphae subrectae vel anfractuae, alternate vel opposite acuteque ramosae, densae reticulatae, cellulis 15.5-40 x 6-9.5 µm. Hyphopodia capitata alternata, ad 20% opposita, recta vel diverse curvula, antrorsa vel subantrorsa vel patentia, 15-18.5 µm longa; cellula basali cylindracea vel cuneata, 5-6.5 µm longa; cellula apicali ovata, globosa, integra, recta vel curvula, 10-12.5 x 12-15.5 µm. Phialis illis hyphopodia commixta, alternata vel opposita, ampullacea, 15-22 x 9-12.5 µm. Setae myceliales numerosae, simplices, rectae, acutae vel obtusae ad apicem, ad 660 µm longae. Perithecia laxe aggregata, ad 200 µm; cellula peritheciales protruda; ascosporae obovoidae, 4-septatae, constrictae, 31-43.5 x 12.5 - 18.5 µm.

Colonies epiphyllous, rarely emphigenous, dense, up to 4 mm in diameter, confluent. Hyphae substraight to crooked, branching alternate to opposite at acute angles, closely reticulate, cells 15.5-40 x 6-9.5 µm. Capitate hyphopodia alternate, about 20% opposite, straight to variously curved, antrorse to subantrorse to spreading, 15-18.5 µm long; head cells ovate, globose, entire, straight to curved, 10-12.5 x 12-15.5 µm. Phialides mixed with capitate hyphopodia, alternate to opposite, ampulliform, 15-22 x 9-12.5 µm. Mycelial setae numerous, simple, straight, acute to obtuse at the apex, up to 200 um; perithecial cells protruding; ascospores obovoidal, 4-septate, constricted at septa, 31-43.5 x 12.5-18.5 µm.

Holotype: On leaves of Bhesa indica (Bedd.) Ding Hou (Celastraceae), Koomati, Valparai, Coimbatore, Dec. 26, 1990, V.B. Hosagoudar HCIO 30535.

This species is close to Meliola lophopetali Stev. ex Hansf. (Beeli formula 3113.4223) reported on Lophopetalum toxicum from the Philippines (Hansford, 1961) but differs from it in having dense, epiphyllous colonies, substraight to crooked mycelia, numerous and longer mycelial setae, larger perithecia and ascospores.

18. **Meliola bicornis** Wint., Hedwigia 25: 99, 1886.
On leaves of _Desmodium_ _velutinum_ (Willd.) DC. (_D_. _latifolium_ (Roxb. ex Ker) Dc.) (Fabaceae), Koomati, Valparai, Coimbatore, Dec. 26, 1990, V.B. Hosagoudar HCIO 30532; on _D_. _telifolia_ (Fabaceae), Koomati, Valparai, Coimbatore, Dec. 26, 1990, V.B. Hosagoudar HCIO 30533; on _D_. _triangulare_ (Retz.) Merr. (Fabaceae), Koomati, Valparai, Coimbatore, Dec. 26, 1990, V.B. Hosagoudar HCIO 30534.

19. **Meliola capensis** (K. & C.) Theiss. var. **malayensis** Hansf., Sydowia 10: 67, 1957.

On leaves of _Schleichera_ _oleosa_ (Lour.) Oken, (Sapindaceae), Loomati, Valparai, Coimbatore, Dec. 26, 1990, V.B. Hosagoudar HCIO

20. **Meliola ceropegia** V.B. Hosagoudar et V.S. Ramachandran, sp. nov. (Fig. 7).

Plagulae amphigenae, plerumque epiphyllae, densae, velutinae, ad 2 mm diam., raro confluentes. Hyphae rectae vel undulatae, opposita acuteque ramosae, laxe vel densae reticulatae, cellulis 24-37.5 x 6-8 µm. Hyphopodia capitata alternata et ad 1% opposita, plerumque recta vel raro curvula, antrosa vel subantrorsa, 18-22 µm longa; cellula basali cylindracea, 5-6.5 µm longa; cellula apicali ovata, globosa, integra vel angulosa vel leniter lobata, 12-15.5 x 10-15.5 µm. Phialis numerosa, illis hyphopodia capitatis commixta, plerumque opposita, ampullacea, 18-22 x 9-12.5 µm. Setae myceliales numerosa, plerumque circa perithecia aggregatae, rectae, simplices, acutae vel obtusae ad apicem, raro geniculatae vel curvulae ad apicem, ad 330 µm longae. Perithecia dispersa, ad 130 µm; ascospores cylindraceae, 4-septatae, leniter constrictae ad septae, 30-35 x 12-15.5 µm.

Colonies amphigenous, mostly epiphyllous, dense, velvety, up to 2 mm in diameter, rarely confluent. Hyphae straight to undulating, branching mostly opposite at acute angles, loosely to closely reticulate, cells 24-37.5 x 6-8 µm. Capitate hyphopodia alternate and about 1% opposite, mostly straight but rarely curved, antrorse to subantrorse, 18-22 µm long; stalk cells cylindrical, 5-6.5 µm long; head cells ovate, globose, entire, angular to slightly lobate, 12-15.5 x 10-15.5 µm. Phialides numerous, mixed with capitate hyphopodia, mostly opposite, ampulliform, 18-22 x 9-12.5 µm. Mycelial setae numerous, mostly grouped around perithecia, straight, simple, acute to obtuse at tip, rarely geniculate to curved at apex, up to 330 µm long. Perithecia scattered, up to 130 µm;

ascospores cylindrical, 4-septate, slightly constricted at septa, 30-35 x 12-15.5 µm.

Holotype: On leaves of Ceropegia sp. (Asclepiadaceae), Agumbe, Shimoga, Karnataka, Oct. 2, 1990, V.S. Ramachandran HCIO 30537.

Meliola hoyae Sacc. and M. tylophorae Hosagoudar are the only two species on asclepiadaceous hosts having opposite capitate hyphopodia (Hansford, 1961; 1963; Hosagoudar & Goos, 1990), M. ceropegiae differs in having phialides mixed with capitate hyphopodia. The head cells of the capitate hyphopodia are ovate, globose, entire to sublobate, distinguishing this species from other Meliola species reported on the membes of the host family Asclepiadaceae.

21. **Meliola chandrasekharanii** Hosagoudar in Hosagoudar & Goos, Mycotaxon 37: 225, 1990.

On leaves of Nothopodytes nimmoniana (Graham) Mabberley (Icacinaceae), Shankarankudi, Valparai, Coimbatore, Dec. 27, 1990, V. B. Hosagoudar HCIO 30538.

22. **Meliola citricola** Sydow, Ann. Mycol. 15: 183, 1917.

On leaves of Citrus aurantium L. (Rutaceae), Shankarankudi, Valparai, Coimbatore, Dec. 27, 1990, V.B. Hosagoudar HCIO 30539.

23. **Meliola clausenae** Hosagoudar ex Hosagoudar & Goos, Mycotaxon 37: 226, 1990.

On leaves of Clausena indica (Dalz.) Oliver (Rutaceae), Top slip, Coimbatore, Dec. 20, 1990, V.B. Hosagoudar HCIO 30540.

This species is close to M. citricola Sydow but differs in forming distinct and isolated colonies, in contrast to a sooty appearance. Though the mycelium is closely reticulate, it never forms solid mycelial plates

24. **Meliola connari** Yates var. **indica** Hosagouda, var. nov. (Fig. 8)

Differt a var. connari plagulae tenuis, hyphae mycelii rectae, setae mycelii et perithecia brevioribus.

Colonies epiphyllous, thin, up to 2 mm in diam. rarely confluent. Hyphae straight, branching alternate to opposite at wide angles, loosely reticulate, cells 12-46.5 x 6-9.5 µm. Capitate hyphopodia alternate, antrorse, subantrorse to rarely spreading, 24-46 µm long; stalk cells cylindrical to cuneate, 6-15.5 µm long; head cells ovate, globose, cylindrical, often curved, entire to angular to slightly lobate, 15-31 x 12-18.5 µm. Phialides mixed with capitate hyphopodia, alternate to opposite, ampulliform, 21-28 x 9-12.5 µm. Mycelial setae few, mostly grouped around perithecia, simple, straight, acute, up to 672 µm long. Perithecia scattered, up to 140 µm; ascospores obovoidal, 4-septate, constricted, 45-50 x 21-25 µm.

Holotype: On leaves of Connarus sclerocarpus Schell. (Connaraceae), Shankarankudi, Valparai, Coimbatore, Dec. 27, 1990, V.B. Hosagoudar HCIO 30541.

The new variety indica differs from the var. connari in having only epiphyllous, thin colonies, straight mycelium, and smaller mycelial setae and perithecia.

25. **Meliola erythrinae** Sydow, Ann. Mycol. 15: 185, 1917.
On leaves of Erythrina variegata L. (Fabaceae), near Manambuli power house, Valparai, Coimbatore, Dec. 26, 1990, V.B. Hosagoudar HCIO 30545.

Uppal et al. (1935) and Srinivasulu (1974) have reported this species from Maharashtra but the materials are not available in any Indian herbaria.

26. **Meliola gamblei** Hosagoudar, sp. nov. (Fig. 9)

Plagulae epiphyllae, densae, crustosae, ad 2 mm in diam., confluentes. Hyphae subrectae vel anfractuae, opposite acuteque ramosae, laxe vel densae reticulatae, cellulis 18-31 x 6-9 µm. Hyphopodia capitata alternata, recta vel curvula, antrorsa vel patentia, 18-22 µm longa; cellula basali cylindracea vel cuneata, 4-5 µm longa; cellula apicali recta vel curvula, ovoidea vel globosa, atenuata et rotundata ad apicem, integra, 12-15.5 x 12-14 µm. Phialis illis hyphopodia capitatis commixta, opposita vel alternata, ampullacea, 15-25 x 6-9.5 µm. Setae myceliales paucae, rectae, simplices, acutae vel obtusae ad apicem, ad 650 µm longae. Perithecia dispersa, verrucosa, ad 280 µm; ascosporae obovoidae, 4-septatae, leniter constrictae, 37-43.5 x 15-18.5 µm.

Colonies epiphyllous, dense, crustose, up to 2 mm in diam., confluent. Hyphae substraight to crooked, branching opposite at acute angles, loosely to closely reticulate, cells 18-31 x 6-9 µm. Capitate hyphopodia alternate, straight to curved, antrorse to spreading, 18-22 µm long; stalk cells cylindrical to cuneate, 4-5 µm long; head cells straight to curved, ovoid to globose, often bluntly pointed at apex, entire, 12-15.5 x 12-14 µm. Phialides mixed with capitate hyphopodia, opposite to alternate, ampulliform, 15-25 x 6-9.5 µm. Mycelial setae few, straight, simple, acute to obtuse at apex, up to 650 µm long. Perithecia scattered, verrucose, up to 280 µm;

ascospores obovoidal, 4-septate, slightly constricted, 37-43.5 x 15-18.5 µm.

Holotype: On leaves of Smilax zeylanica L. (Smilacaceae), Kombar, South Canara, Karnataka, Dec. 16, 1918, J.S. Gamble HCIO 30546.

To date, six taxa of the genus Meliola are known on the members of the family Smilacaceae. Of these, M. gamblei is closest to M. salleana Hansf., from which it differs in having crooked mycelium, smaller and entire capitate hyphopodia, and phialides mixed with capitate hyphopodia. It also differs from M. salleana Hansf. var. smilacis Hosagoudar in having dense and crustose colonies with crooked mycelium.

27. **Meliola glycosmidis** Kapoor, Indian Phytopath. 20: 153, 1967.

On leaves of Glycosmis pentaphylla Brogn. (Rutaceae), Erameparai, Top slip, Coimbatore, Dec. 20, 1990, V.B. Hosagoudar HCIO 30548.

28. **Meliola gneti** Hansf., Reinwardtia 3: 85, 1954.

On leaves of Gnetum ula Brogn. (Gnetaceae), Koomati, Valparai, Coimbatore, Dec. 26, 1990, V.B. Hosagoudar HCIO 30547.

29. **Meliola groteana** Sydow, Ann. Mycol. 11: 402, 1913.

On leaves of Maesa indica (Roxb.) DC. (Myrsinaceae), near Sholayar dam, Valparai, Coimbatore, Dec. 25, 1990, V.B. Hosagoudar HCIO 30549.

30. **Meliola holigarnae** Stev., Mem. Dept. Agric. India Bot. Ser. 15: 108, 1928.

On leaves of Holigarna grahamii (Wight) Kurz (Anacardiaceae), Koomati, Valparai, Coimbatore, Dec. 26, 1990, V.B. Hosagoudar HCIO 30550.

31. **Meliola linocierae-malabaricae** Hosagoudar, Nova Hedwigia 47: 540, 1988.

On leaves of Linociera malabarica Wall. (Oleaceae), Koomati, Valparai, Coimbatore, Dec. 26, 1990, V.B. Hosagoudar HCIO 30551.

32. **Meliola malabarensis** Hansf., Proc. Linn. Soc. London 157: 187, 1946.

On leaves of Olea dioica Roxb. (Oleaceae), Koomati, Valparai, Coimbatore, Dec. 26, 1990, V.B. Hosagoudar HCIO 30552.

33. **Meliola malacotricha** Speg. var. **major** Beeli, Bull. Jard. Bot. Bruxelles 7: 89, 1920.

On leaves of Argyeria setosa (Roxb.) Choisy (Convolvulaceae), Top slip, Coimbatore, Dec. 20, 1990, V.B. Hosagoudar HCIO 30553.

34. **Meliola memecylicola** Hansf. var. **indica** Hosagoudar, var. nov. (Fig. 10)

Differt a var. memecylicola setae myceliales longioribus, ascosporae magniorae.

Colonies amphigenous, mostly epiphyllous, subdense, up to 2 mm in diameter. Hyphae straight, branching opposite at cute to wide angles, loosely reticulate, cells 18-22 x 6-9.5 µm. Capitate hyphopodia alternate and about 20% opposite, subantrorse, 15-18.5 µm long; head cells ovate, cuneate, entire, 9-12.5 x 9-11 µm. Phialides mixed with capitate hyphopodia, alternate to opposite, ampulliform, 21-25 x 9-12.5 µm. Mycelial setae few, grouped around perithecia, straight, simple, acute, up to 575 µm long. Perithecia scattered, up to 100 µm; ascospores obovoidal, 4-septate, constricted, 37-58 x 15-18.5 µm.

Holotype: On leaves of Memecylon depressum Benth. (Melastomataceae), Top slip, Coimbatore, Dec. 20, 1990, V.B. Hosagoudar HCIO 30554.

35. **Meliola panici** Earle, Muehlenbergia 1: 12, 1901.

On leaves of Centotheca lappacea (Linn.) Desv. (Poaceae), Koomati, Valparai, Coimbatore, Dec. 26, 1990, V.B. Hosagoudar HCIO 30555; on leaves of Lophotherum gracile Brongn. (Poaceae), Koomati, Valparai, Coimbatore, Dec. 26, 1990, V.B. Hosagoudar HCIO 30556.

36. **Meliola parvula** Sydow, Leafl. Philipp. Bot. 6: 1925, 1913.

On leaves of Aglaia sp. (Meliaceae), Manjiparai, Sheikalmudy, Valparai, Coimbatore, March 26, 1990, V.B. Hosagoudar HCIO 30557.

37. **Meliola pulchella Speg.** var. **syzygii** Hosagoudar, var. nov. (Fig. 11)

Differt a var. pulchella hyphopodia capitata longa et raro flexuosa, ascosporae magniorae.

Colonies epiphyllous, very thin, diffused. Hyphae substraight to flexuous, branching alternate to irregular at acute angles, loosely reticulate, cells 27-45 x 6-8 µm. Capitate hyphopodia alternate, straight to curved, antrorse to reflexed, rarely flexuous to crooked, 21-28 µm long; stalk cells cylindrical to cuneate, 6-9.5 µm long; head cells ovate, globose, entire to slightly and irregularly sublobate, 15-18.5 x 9-12.5 µm. Phialides mixed with capitate hyphopodia, alternate to opposite, ampulliform, 21-28 x 9-12.5 µm. Mycelial setae very few, straight, acute to obtuse at apex, up to 300 µm long. Perithecia scattered, up to 170 µm; ascospores obovoidal to ellipsoidal, 3-septate, mostly curved, 43-50 x 15-17 µm.

Holotype: On leaves of Syzygium laetum (Buch.-Ham.) Gandhi (Myrtaceae), near Manambuli power house, Valparai, March 28, 1990, V.B. Hosagoudar HCIO 30558.

There is only one species, M. pulchella Speg., with thin colonies and 3-septate ascospores known on the members of the family Myrtaceae from Brazil (Hansford, 1961). The new variety differs from the var. pulchella in having longer and rarely flexuous capitate hyphopodia and larger ascospores.

38. **Meliola teramni** Sydow var. **millettiae** Hosagoudar, var. nov. (Fig. 12)

Differt a var. teramni hyphopodia capitata 5% opposita nulla, setae myceliales brevioribus et acute ad apicem.

Colonies amphigenous, dense to subdense, crustose to velvety, up to 4 mm in diameter, confluent. Hyphae substraight to slightly crooked, branching opposite to irregular at acute angles, loosely to closely reticulate, cells 21-28 x 6-8 µm. Capitate hyphopodia alternate, antrorse, subantrorse to spreading, straight to curved, 18-22 µm long; stalk cells cuneate to cylindrical, 6-9.5 µm long; head cells ovate, globose, rarely truncate at apex, entire, 12-15 x 10-15 µm. Phialides mixed with capitate hyphopodia, opposite to alternate, ampulliform, 15-18.5 x 9-12.5 µm. Mycelial setae very few, straight, simple, acute to bifid to rarely cristate, up to 790 µm long. Perithecia scattered, up to 140 µm; ascospores ellipsoid to cylindrical, 4-septate, constricted, 37-40.5 x 12-15.5 µm.

Holotype: On leaves of Millettia rubiginosa Wight & Arn. (Fabaceae), Shankarankudi, Valparai, Coimbatore, Dec. 27, 1990, V.B. Hosagoudar HCIO 30559.

The new variety differs from the var. teramni in lacking 5% opposite capitate hyphopodia, and in having smaller mycelial setae that are mostly acute to 2-dentate, but not furcate.

39. **Meliola travancoricae** Hosagoudar, sp. nov. (Fig. 13)

Plagulae epiphyllae, densae, crustosae, ad 2 mm in diam. Hyphae rectae vel subrectae, plerumque opposite acuteque vel laxe ramosae, densae reticulatae, cellulis 12-15.5 x 8-9.5 µm. Hyphopodia capitata alternata, antrorsa vel patentia, recta vel curvula, 18-22 µm longa; cellula basali cylindracea vel cuneata, 3-6.5 µm longa; cellula apicali ovata, integra, 14-16 x 10-12.5 µm. Phialis illis hyphopodia capitatis commixta, alternata vel opposita, ampullacea, 15-22 x 12-15.5 µm. Setae myceliales numerosae, simplices, rectae, acutae vel obtusae, ad 500 µm longae. Perithecia dispersa, globosa, ad 200 µm; cellulae peritheciales protrudae, ad 10 µm longae; ascosporae ellipsoideae, 4-septatae, constrictae, 43-46.5 x 18-22 µm.

Colonies epiphyllous, dense, crustose, up to 2 mm in diameter. Hyphae straight to substraight, branching mostly opposite at acute to wide angles, closely reticulate, cells 12-15.5 x 8-9.5 µm. Capitate hyphopodia alternate, antrorse to spreading, straight to curved, 18-22 µm long; stalk cells cylindrical to cuneate, 3-6.5 µm long; head cells ovate, entire, 14-16 x 10-12.5 µm. Phialides mixed with capitate hyphopodia, alternate to opposite, ampulliform, 15-22 x 12-15.5 µm. Mycelial setae fairly numerous, simple straight, acute to obtuse at the apex, up to 500 µm long. Perithecia scattered, globose, up to 200 µm; perithecial cells projecting, up to 10 µm long; ascospores ellipsoidal, 4-septate, constricted, 43-46.5 x 18-22 µm.

Holotype: On leaves of Semecarpus travancorica Bedd. (Anacardiaceae), Koomati, Valparai, Coimbatore, Dec. 26, 1990, V.B. Hosagoudar HCIO 30560.

This species is close to Meliola semecarpicola Hansf. but differs from it in not causing leaf spots, in having smaller capitate hyphopodia and mycelial setae, in forming larger perithecia, and in having the capitate hyphopodia mixed with phialides.

40. **Meliola trewiae** Hosagoudar sp. nov. (Fig. 14)

Plagulae epiphyllae, tantum tenuis, ad 4 mm diam., confluentes. Hyphae flexuosae, opposite vel alternate acuteque ramosae, laxe reticulatae, cellulis 30-34 x 8-9.5 µm. Hyphopodia capitata alternata, antrorsa vel subantrorsa, 12-18.5 µm longa; cellula basali cylindracea vel cuneata, 3-6.5 µm longa; cellula apicali ovata vel globosa, integra, 9-12.5 x 10-12.5 µm. Phialis illis hyphopodia capitatis commixta, alternata vel opposita, ampullacea, 12-18.5 x 9-12.5 µm. Setae myceliales paucae, circa perithecia aggregatae vel disseminatae, simplices, rectae, obtusae, ad 300 µm longae. Perithecia disseminata, verrucosa, ad 124 µm;

ascosporae obovoideae, 4-septatae, constrictae, 31-34 x 12-15.5 µm.

Colonies epiphyllous, very thin, up to 4 mm in diameter, confluent. Hyphae flexuous, branching opposite to alternate at acute angles, loosely reticulate, cells 30-34 x 8-9.5 µm. Capitate hyphopodia alternate, antrorse to subantrorse, 12-18.5 µm long; stalk cells cylindrical to cuneate, 3-6.5 µm long; head cells ovate to globose, entire, 9-12.5 x 10-12.5 µm. Phialides mixed with capitate hyphopodia, alternate to opposite, ampulliform, 12-18.5 x 9-12.5 µm. Mycelial setae few, grouped around perithecia and also scattered, simple, straight, obtuse, up to 300 µm long. Perithecia scattered, verrucose, up to 124 µm; ascospores obovoidal, 4-septate, constricted, 31-34 x 12-15.5 µm.

Holotype: On leaves of Trewia polycarpa Benth. ex Hook. (Euphorbiaceae), Koomati, Valparai, Coimbatore, Dec. 26, 1990, V.B. Hosagoudar HCIO 30561; paratype: On leaves of T. nodiflora L. (Euphorbiaceae), Koomati, Valparai, Coimbatore, Dec. 26, 1990, V.B. Hosagoudar HCIO 30562.

41. **Meliola zanthoxyli** Hansf., Proc. Linn. Soc. London 158: 37, 1946.

On leaves of Zanthoxylum tetraspermum Wight & Arn. (Rutaceae), Kollimalai, Tamil Nadu, Nov. 1, 1914. J.S. Gamble HCIO 30563.

ACKNOWLEDGEMENTS

We are grateful to Dr. N.P. Balakrishnan, Deputy Director, and Dr. A.N. Henry, Scientist SE, Botanical Survey of India, Southern Circle, Coimbatore for the encouragement; to Dr. V.J. Nair, Scientist SD, Mr. K. Vivekananthan, Scientist B and Mr. P. Bhargavan, Senior Scientific Assistant of the same organization for their help in identifying of the host plants. We are most grateful to Dr. Gareth Morgan-Jones for reviewing the manuscript and for many helpful suggestions.

REFERENCES

Hansford, C.G. 1961. The Meliolineae. A Monograph. *Sydowia* Beih. 2: 1-806

Hansford, C.G. 1963. Iconographia Meliolinearum. *Ibid*. Beih. 5: pls. I-CCLXXXV.

Hosagoudar, V.B. and R.D. Goos. 1990. Meliolaceous fungi from the State of Kerala, India-II. *Mycotaxon* 37: 217-272.

Hu, Y. and D. Lu. 1986. The Meliolaceae of Dinghu Shan biosphere reserve. *Acta Mycol. Sinica*, Suppl. I. 1: 77-81.

Katumoto, K. and V.B. Hosagoudar. 1989. Supplement to Hansford's "The Meliolineae Monograph." J. Econ. Tax. Bot. 13: 615-635.

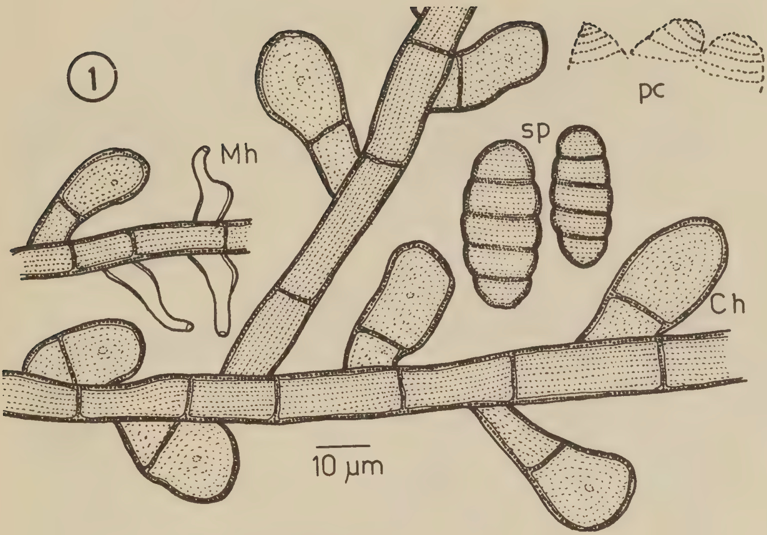
Mueller, W.C., R.D. Goos, J. Quainoo and A.T. Morgham. 1991. The structure of the phialides (mucronate hyphopodia) of the Meliolaceae. Can. J. Bot. (In Press)

Srinivasulu, B.V. 1974. Genus *Meliola* from Maharashtra State. *Nova Hedwigia* Beih. 47: 421-437.

Uppal, B.N., Patel, M.K. and M.N. Kamat. 1935. The Fungi of Bombay VIII: 1-56.

Abbreviations used in figures:

Ch - Capitate hyphopodia
Mh - Phialide
Ms - Mycelial setae
Pc - Perithecial cells
PS - Perithecial setae


1
Mh
pc
sp
Ch
10 µm

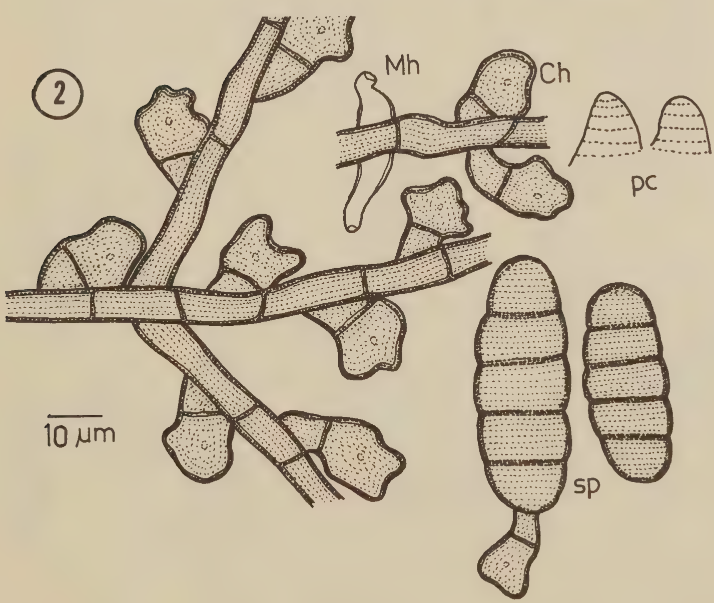
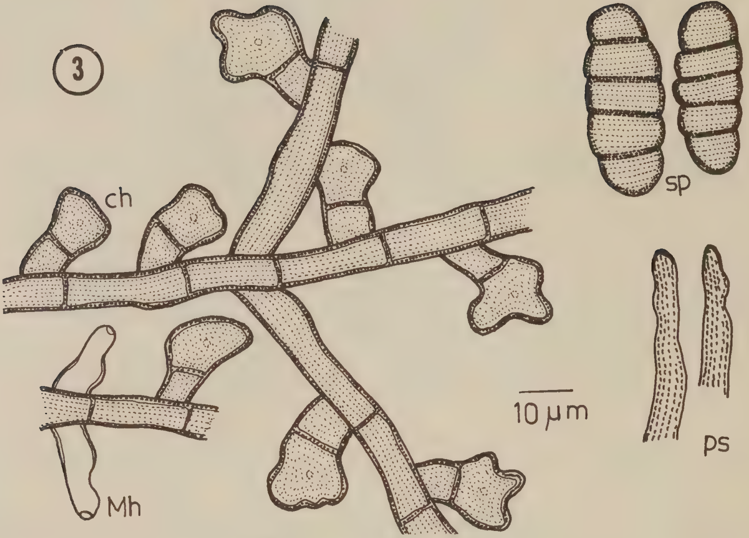

2
Mh
Ch
pc
10 µm
sp

Fig. 1. Asteridiella acronychiae-pedunculatae Hosagoudar.
Fig. 2. Asteridiella anamalainana Hosagoudar.


3
ch
sp
ps
10 µm
Mh

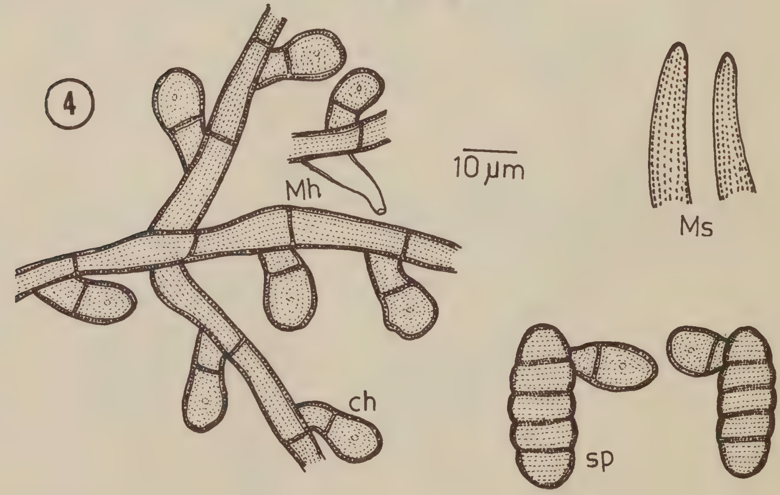
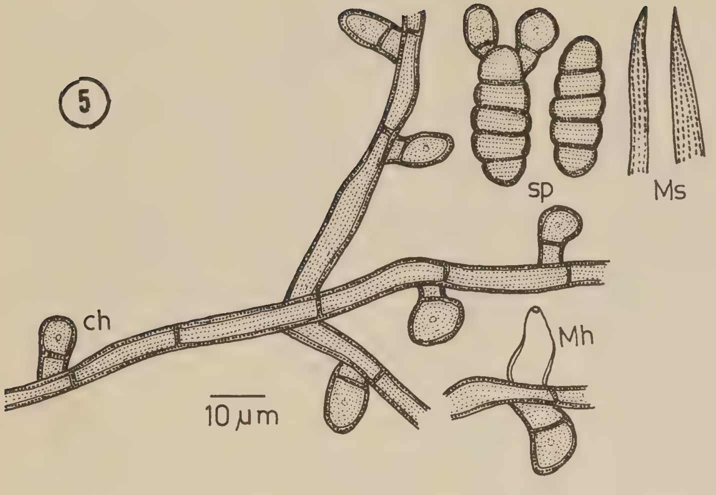

4
Mh
10 µm
Ms
ch
sp

Fig. 3. Irenopsis xanthophylli Hosagoudar.
Fig. 4. Meliola altissimae Hosagoudar.

5


sp
Ms
ch
Mh
10 µm

6

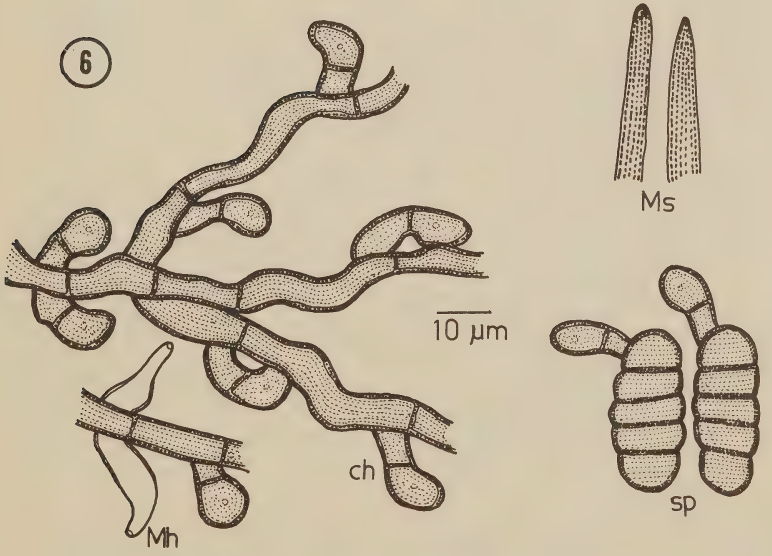
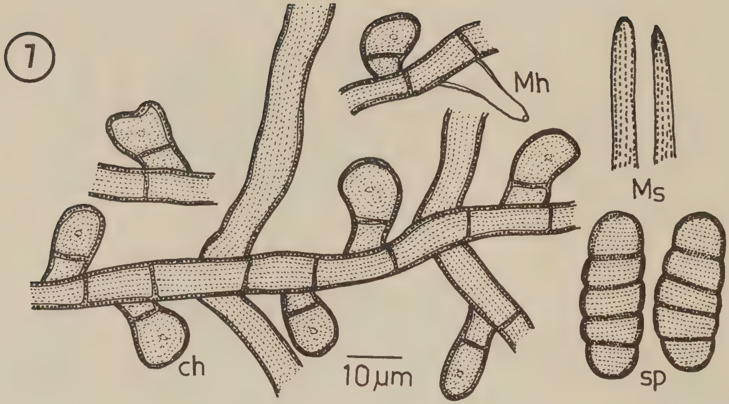

Ms
10 µm
sp
ch
Mh

Fig. 5. *Meliola banosensis* Sydow var. *puereriae* Hosagoudar.

Fig. 6. *Meliola bhesae* Hosagoudar.


7
Mh
Ms
ch
10 µm
sp

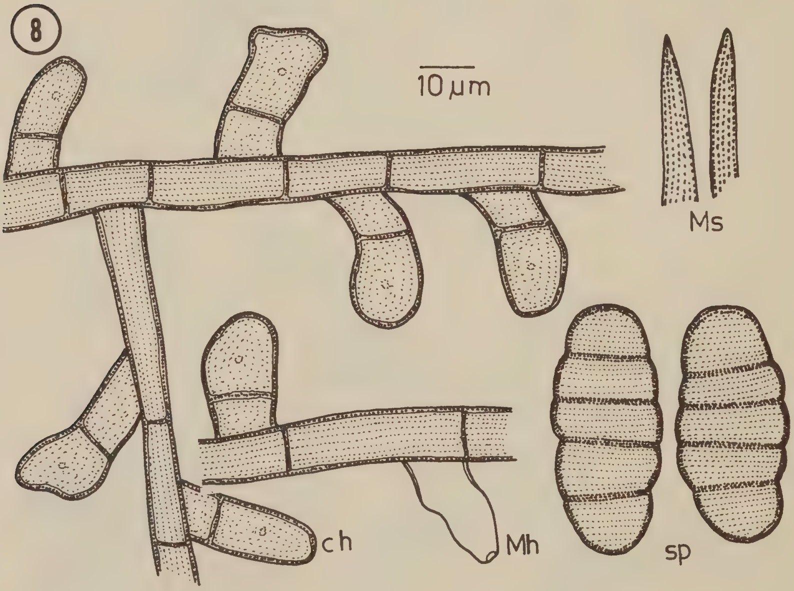
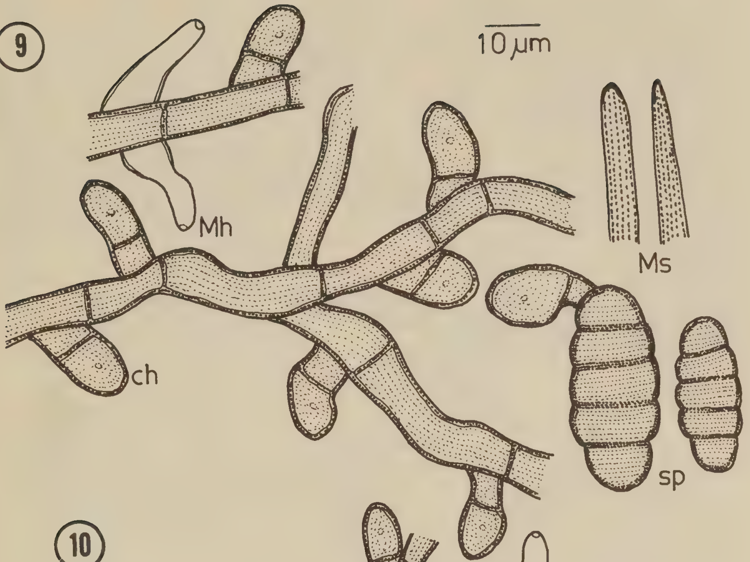

8
10 µm
Ms
ch
Mh
sp

Fig. 7. Meliola ceropegiae Hosagoudar.
Fig. 8. Meliola connari Yates var. indica Hosagoudar.

⑨


10 µm
Mh
Ms
ch
sp

⑩

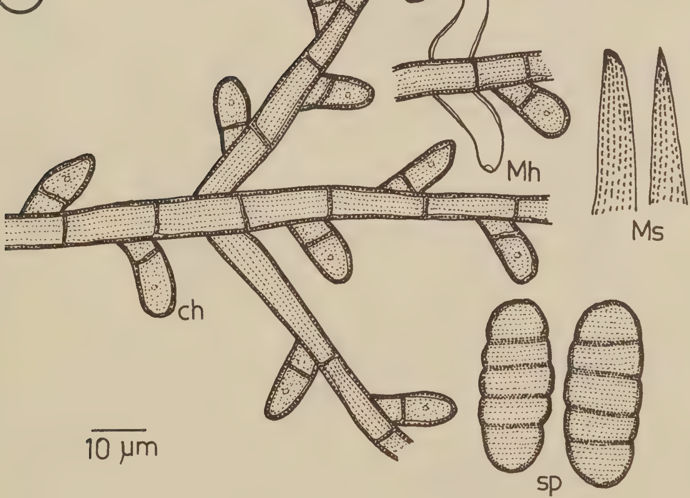
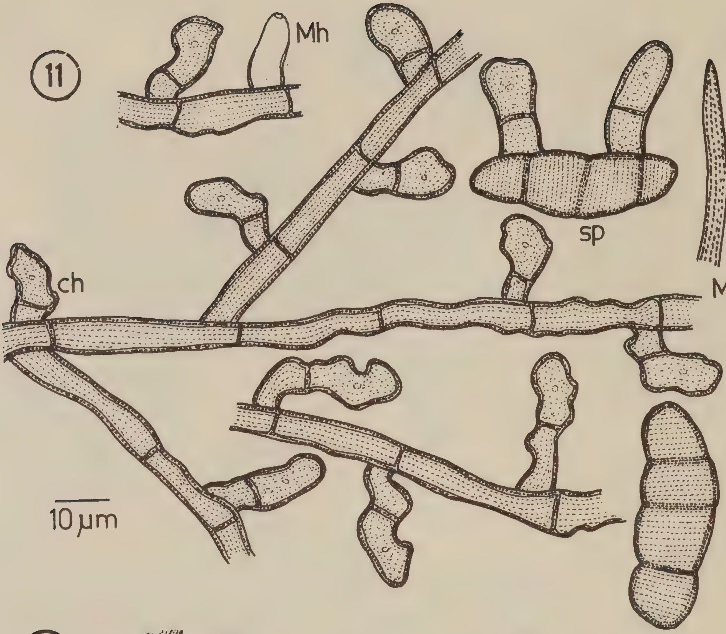

Mh
Ms
ch
10 µm
sp

Fig. 9. *Meliola gamblei* Hosagoudar.
Fig.10. *Meliola memecylicola* Hansf. var. *indica* Housagoudar


11
Mh
ch
sp
Ms
10 µm

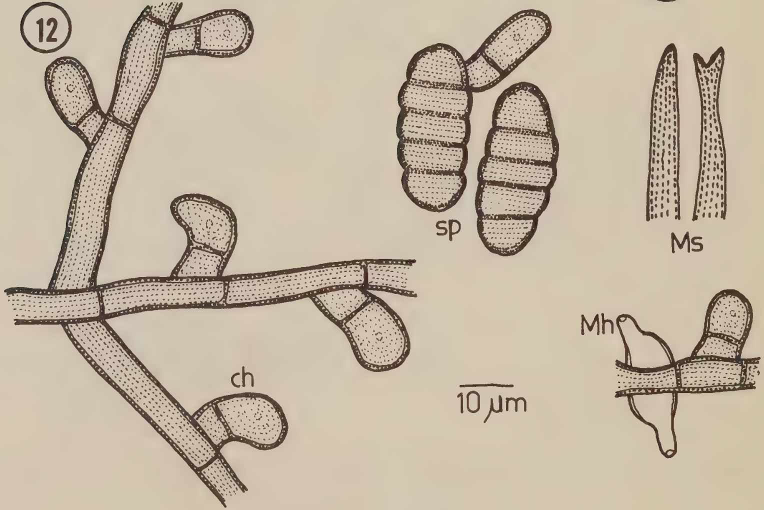
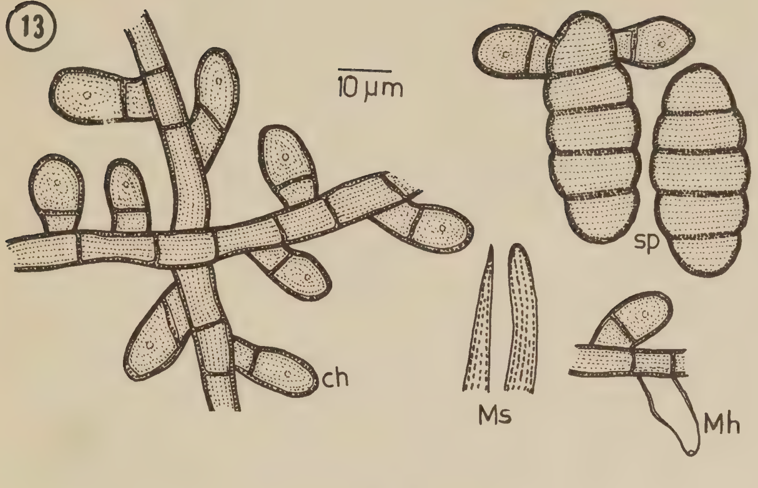

12
sp
Ms
Mh
ch
10 µm

Fig. 11. Meliola pulchella Speg. var. syzygii Hosagoudar.
Fig. 12. Meliola terami Sydow var. millettiae Housagoudar


13
10 µm
sp
Ms
Mh
ch

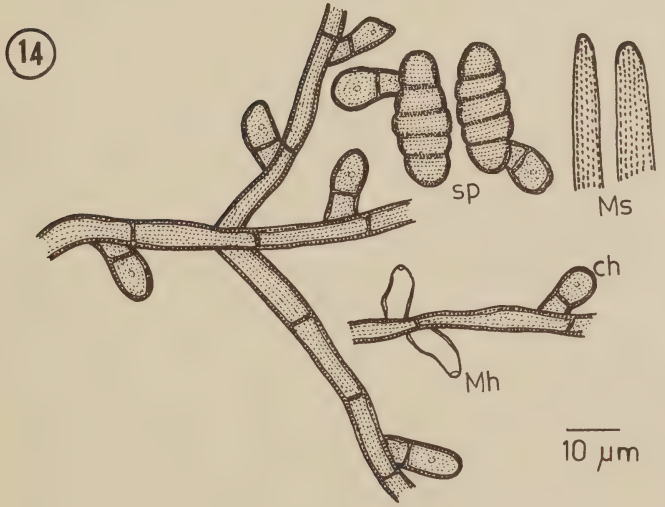

14
sp
Ms
ch
Mh
10 µm

Fig. 13. *Meliola travancoricae* Hosagoudar.
Fig. 14. *Meliola trewiae* Hosagoudar.

MYCOTAXON

Volume XLII, pp. 149-154 October-December 1991

Athelopsis instead of Pteridomyces (Corticiaceae, Basidiomycetes)

Kurt Hjortstam
Målaregatan 12
S–441 35 Alingsås, Sweden

The genus *Pteridomyces* Jülich is reduced to synonymy under *Athelopsis* Oberw. ex Parm. The following new combinations are proposed: *Athelopsis galzinii* (*Epithele galzinii* Bourd.), *A. bananispora* (*Pteridomyces bananisporus* Boid. & Gilles) and *Hyphodontia capitata* (*Pteridomyces capitatus* Boid. & Gilles). *Hyphodontia bugellensis* (Ces.) Erikss. is re-introduced and the difference in comparison with *H. pruni* (Lasch) Svrcek is discussed. A key to the species of *Athelopsis* is provided.

INTRODUCTION

Pteridomyces is considered as a synonym of *Athelopsis* in spite of the fact that the basidiome of *Epithele galzinii* is closely adnate and not, as in typical species of *Athelopsis*, loosely attached and pellicular. Further, it is provided with hyphal pegs. The latter are seemingly analogous to those of species of *Epithele* (Pat.) Pat., but these characters can hardly be considered significant at generic level. The chief characteristics of *Epithele* are the large basidia, often 50–75 × 9–12 µm and smooth or more rarely slightly rugose spores measuring about 10–12 × 6–12 µm. In some species also skeletal hyphae occur.

Pteridomyces was originally described as odontioid and with a monomitic hyphal system, but Boidin and Lanquetin (1983) emended the genus in a broader sense to include species with skeletal hyphae. It is, however, obvious from a micromorphological point of view, that *Epithele galzinii* is strikingly similar to the circumscription of *Athelopsis.* This can especially be emphasized by the form of the basidia and spores in that species. The former are typically pedunculate or, in some species at least, almost so and the latter are ellipsoid with an allantoid appearance, exactly as in *Athelopsis lacerata* (Litsch.) Erikss. & Ryv. and *A. lembospora* (Bourd.) Oberw.

Eriksson and Ryvarden (1973) were aware of this similarity and stated: "Even if rather few basidia are typically stalked, it seems to match the genus *Athelopsis* sufficiently well". Consequently the following new combination is proposed:

Athelopsis galzinii (Bres.in Bourd. & Galz.) Hjortst. comb.nov.
Basionym: *Epithele galzinii* Bres. in Bourd. & Galz. in Bull. trimest. Soc. Mycol. Fr. 27:264 (1911).

ATHELOPSIS OBERW. EX PARM.

Conspectus syst. corticiacearum (Tartu) p. 41 (1968).
Generic type: *Corticium glaucinum* Bourd. & Galz.
Generitype specimen: (Holotype) France, Aveyron, 12 June 1910. (PC).
Synonym: *Pteridomyces* Jülich in Persoonia 10:331 (1979); emend. Boidin and Lanquetin in Mycotaxon 16:486 (1983).
Generic type: *Epithele galzinii* Bres. in Bourd. & Galz.
Generitype specimen: (Lectotype) France, Aveyron, on *Polystichum filix-mas*, 9 June 1910, leg. Bourdot 7369 (PC). Designated by Hjortstam (1987).

Description:
BASIDIOME resupinate, thin, closely adnate to mostly pellicular, smooth or with sterile (i. e. no basidia) "hyphal pegs" (epithelioid), whitish to pale yellowish, sometimes with a faint tint of green.
HYPHAL SYSTEM monomitic; subhymenial hyphae mostly thin-walled, basal hyphae usually rather straight and thin-walled or slightly thick-walled. All hyphae with or more rarely without clamp-connexions.
CYSTIDIA absent or present.
BASIDIA clavate to more or less obconical, mostly pedunculate, normally with four sterigmata.
SPORES normally 5–10 µm long, hyaline, ellipsoid to cylindrical, often with an allantoid appearance, thin-walled, smooth, inamyloid or rarely amyloid (only *A. lacerata*). For description and figure of *A. glaucina* see Eriksson and Ryvarden (1973).

Some of the species, but not the generic type, occur exclusively on ferns.

Description of *A. galzinii*:
BASIDIOME resupinate, closely attached to the substratum, whitish, thin.
HYPHAL PEGS abundant, 10–12/mm, 0.1–0.3 mm long, consisting of closely united, somewhat sinuous hyphae, 2.5–3 µm wide, with clamp-connexions.
HYPHAL SYSTEM monomitic; hyphae thin-walled, 1.5–3 µm wide, with clamp-connexions.
CYSTIDIA absent, but now and then with narrow hyphal ends.
BASIDIA at first clavate, then distinctly pedunculate, with four sterigmata and a basal clamp-connexion.
SPORES generally few (presumably a reliable characteristic), somewhat allantoid, thin-walled, smooth, (5–)8–10 × 2.5–3.5 µm, often agglutinated in groups of 2–4.

The species seems to occur exclusively on ferns. There is a good illustration in Bourdot and Galzin (1928) and in Eriksson and Ryvarden (1975), though in the latter the figured spore is immature.

Species described in Pteridomyces.

Pteridomyces bananisporus Boid. & Gilles
Holotype: Mascarene Islands, Réunion, Cilaos, on rachises of Aspidium. (LY 11165).

The microcharacters, especially the spores and basidia, indicate a close relationship with *A. galzinii,* but *P. bananisporus* differs in the denser basidiome with more robust hyphal pegs and the occurrence of capitulate hyphal ends which can best be observed in the aculei. At present the species is considered distinct from *A. galzinii* and the following new combination is proposed:
Athelopsis bananispora (Boid. & Gilles) Hjortst. comb. nov.
Basionym: *Pteridomyces bananisporus* Boid. & Gilles in Bull. trimest. Soc. Mycol. Fr. 102:302 (1986).

Pteridomyces bisporus Boid. & Gilles
in Bull. trimest. Soc. Mycol. Fr. 104:65–66 (1988).
Holotype: Mascarene Islands, Réunion, Cilaos, on wood. (LY 12752).

On the basis of the two-sterigmate basidia, absence of clamp-connexions, relatively large and subglobose spores (about 10 µm diam.), and presence of dendrohyphidia the species is reminiscent of *Dendrothele* Höhn. & Litsch. and does not belong in either *Athelopsis* or *Epithele.* It should be noted that in the original description both the generic name and the epithet were omitted on page 66. At present I have no idea as to its most appropriate generic position.

Pteridomyces capitatus Boid. & Gilles
Holotype: Mascarene Islands, Réunion, Bébour, on rachises of Cyathea. (LY 11608). The holotype was mentioned next to the protologue, but in the specimens listed, another collection is given as holotype.

This species is, in contradiction to the statement by Boidin and Gilles (1986), not a typical species of *Pteridomyces.* It is, instead, reminiscent of *Hyphodontia* Erikss., especially *H. bugellensis* (Ces.) Erikss. and *H. pruni* (Lasch) Svrcek., by virtue of hyphal texture, cystidia characters, and constricted, and/or somewhat suburniform basidia, but it has longer spores than either of these species. Further, the aculei are mostly smooth or with a very slight penicillate apex, whereas both *H. bugellensis* and *H. pruni* have somewhat larger aculei which are distinctly penicillate.

For the time being I prefer to place the species in *Hyphodontia* and the following new combination is proposed:
Hyphodontia capitata (Boid. & Gilles) Hjortst. comb. nov.
Basionym: *Pteridomyces capitatus* Boid. & Gilles in Bull. trimest. Soc. Mycol. Fr. 102:303 (1986).

H. bugellensis was placed in synonymy with *H. pruni* by Eriksson and Hjortstam in Eriksson and Ryvarden (1976). However, recently the present author discovered that the two types, see below, constituted two different species. The species are very similar but differ primarily in spore-morphology. In the former these are distinctly thick-walled, though well matured spores should be examined, and they are also shorter, (5–)5.5–6(–6.5) × 3.5–4 µm. In *H. pruni* the spores are thin-walled, and are up to 6.5–7 µm in length.

The full distribution of these species is somewhat uncertain. However, it seems, that *H. bugellensis* does not occur in Northern Europe, but is rather frequent in Southern Europe (Spain, Portugal and Italy). *Hyphodontia pruni,* in contrast, appears to be scattered in Northern Europe, and considerably less recorded in the south.

These species, together with *H. capitata*, have typical cystidia, basidia (though slightly differently shaped in *H. capitata*) and hyphae in accordance with the concept of the genus (see Eriksson and Ryvarden, loc. cit.).

Hyphodontia bugellensis (Ces.) Erikss., in Symb. bot. Ups. 16:104 (1958). — *Odontia bugellensis* Ces. in Bot. Zeitung 13(16):283 (1855); in Rabenhorst–Klotzschii Herb. viv. Mycol. no. 1915 (1855). The type is preserved at S and a portion at K.

Hyphodontia pruni (Lasch) Svrcek, in Ceská Mykol. 27:204 (1973). — *Odontia pruni* Lasch in Bot. Zeitung 9(36):644 (1851); in Rabenhorst–Klotzschii Herb. viv. mycol. no. 1514 (1851). The type is preserved at S and a portion at K.

Pteridomyces lacteus Boid., Lanq. & Gilles
in Mycotaxon 16:486 (1983).
Holotype: Africa, Gabon. (LY 9334)

This species bears a close resemblance to *P. roseolus* (see below) and is mainly separated by its somewhat longer spores. It does not match the concept of *Athelopsis.*

Pteridomyces roseolus Boid. & Lanq.
in Mycotaxon 16:488 81983).
Holotype: Africa, Central African Republic. (LY 5377).

The generic position of this species and *P. lacteus* remains obscure but, without doubt, they do not belong in either *Athelopsis* or in *Epithele.* The aculei seem to be fertile, with the texture rather dense and with hyphae conglutinated and somewhat gelatinized. Further, both have narrowly clavate (never pedunculate) basidia.

On the basis of the aculei,the basidia and the subcylindrical spores these species are reminiscent of *Phlebia verruculosa* Hjortst. & Ryv. However, that species lacks clamp-connexions and does not match the concept of *Phlebia* s. s. Unfortunately, all these species have been recorded only once and further investigation and additional specimens are needed to confirm the generic position.

Pteridomyces sphaericosporus Boid., Lanq. & Gilles
in Mycotaxon 16:490 (1983).
Holotype: Africa, Ivory Coast. (LY 7377).

The holotype represents *Odontiopsis ambigua* (Berk. & Br.) Hjortst., a species originally described from Sri Lanka and in recent years described under the name *Odontiopsis hyphodontina* Hjortst. & Ryv. from Africa (Tanzania). For further comments of the generic concept and delimitation of *Odontiopsis*, see Hjortstam and Ryvarden (1980).

Pteridomyces subsphaericosporus Boid., Duhem & Gilles
in Bull. mens. Soc. linn. Lyon 58:46 (1989).
Holotype: Spain, Caceres, Umbria del Castillo de Monfraqüe. Hjortstam 16271. (LY 12199).

The holotype represents *Hyphodontia bugellensis* (Ces.) Erikss.

It should be mentioned that this species is rather common in Monfraqüe National Park where it has been recorded several times by the present author.

Species accepted in Athelopsis

A. baculifera (Bourd. & Galz.) Jülich
in Willdenowia 6:217 (1971). — *Corticium baculiferum* Bourd. & Galz. Hyménomycètes de France p. 194 (1928).
Known only (?) from the type specimen.

A. bananispora (Boid. & Gilles) Hjortst.

A. crystallifera (Rick ex Rambo) Hjortst.
in Windahlia 17:56 (1987). — *Corticium crystalliferum* Rick in Broteria 7:74 (1938); *A. crystallifera* (Rick ex Rambo) Hjortst. & Ryv. in Mycotaxon 15:261 (1982), combination invalid because the authors cited an incorrect basionym.

A. galzinii (Bres. in Bourd. & Galz.) Hjortst.

A. glaucina (Bourd. & Galz.) Parm.
Conspectus syst. corticiacearum (Tartu) p. 42 (1968). — *Corticium glaucinum* Bourd. & Galz. Hyménomycètes de France p. 207 (1928). Generic type.

A. lacerata (Litsch.) Erikss. & Ryv.
Corticiaceae North Eur. p. 141 (1973). — *Corticium laceratum* Litsch. in Annls mycol. Berlin, 39:118–119 (1941).

A. lembospora (Bourd.) Oberw.
in Persoonia 7:3 (1972. — *Corticium lembosporum* Bourd. in Rev. sci. Bourb. Centr. Fr. 23:210 (1910).

A. subinconspicua (Litsch.) Jülich
in Persoonia 8:292 (1975). — *Corticium subinconspicuum* Litsch. in Bull. Soc. sci. Skopje 18:178–179 (1938).

Key to the species of Athelopsis.

1. Hymenophore smooth 2
1. Hymenophore odontioid 7
2. Spores amyloid. Boreal species . . . . *A. laceratum*
2. Spores inamyloid 3
3. Without clamp-connexions. South America . . . . *A. crystallifera*

3. With clamp-connexions 4
4. Spores ellipsoid, 6–8 × 3.5–4.5 µm. Boreal species and from South America . . . . *A. subinconspicua*
4. Spores differently shaped 5
5. Spores cylindrical, 9–10 µm long, generally glued together in groups of 2–4. Boreal species and from Africa (Tanzania), South America (Tierra del Fuego) . . . . *A. glaucina*
5. Spores shorter, allantoid or sigmoid, usually not glued together 6
6. Spores allantoid, 6–7 µm long. Cosmopolitan species. On ferns . . . . . . *A. lembospora*
6. Spores more or less sigmoid, 6–8 µm long. France . . . . *A. baculifera*
7. Basidiome rather dense, capitulate hyphal ends in the aculei. Réunion . . . . *A bananispora*
7. Basidiome more loose, hyphal ends not capitulate. Europe . . . . *A. galzinii*

ACKNOWLEDGEMENT

I am grateful to Dr B.M. Spooner who read the manuscript and kindly suggested improvements.

REFERENCES

Boidin, J. & Lanquetin, P. 1983. Basidiomycètes Aphyllophorales épithéloïdes étalés. Mycotaxon 16:461–499.

Boidin, J. & Gilles, G. 1986. Basidiomycètes Aphyllophorales de L'île de la Réunion. IV. Les Genres Epithele (Pat.) Pat. et Pteridomyces Jülich. Bull. trimest. Soc. Mycol. Fr. 299–304.

Bourdot, H. & Galzin, A. 1928. Hyménomycètes de France. 761 pp.

Eriksson, J. & Ryvarden, L. 1973. The Corticiaceae of North Europe. Vol. 2. Aleurodiscus – Confertobasidium Fungiflora, Oslo. 1975. The Corticiaceae of North Europe. Vol. 3. Coronicium – Hyphoderma. Fungiflora, Oslo.

— 1976. The Corticiaceae of North Europe. Vol. 4. Hyphodermella – Mycoacia. Fungiflora, Oslo.

Hjortstam, K. 1987. A check-list to Genera and Species of Corticioid fungi (Hymenomycetes). Windahlia 17:55–85.

Hjortstam, K. & Ryvarden, L. 1980. Studies in tropical Corticiaceae (Basidiomycetes) II. Mycotaxon 12:168–184.

MYCOTAXON

Volume XLII, pp. 155-162 October-December 1991

MORPHOLOGY, CYTOLOGY AND TAXONOMY OF HYDNOTRYA CEREBRIFORMIS (PEZIZALES)

Bin-Cheng Zhang *

Department of Mycology, Institute of Microbiology,
Academia Sinica, Beijing 100080, China

Summary

Based on studies of type and other available specimens, the species *Hydnotrya cerebriformis* is circumscribed and illustrated. The apical opening of asci is reported for the first time in the genus, and its evolutionary significance is discussed. Nuclear staining using the Giemsa-HCl technique revealed its ascospores have four nuclei. The taxonomic position of the species in the genus is discussed, based on the results of the present studies, and its retainment in the genus is confirmed. Ascospore ornamentation is also studied using SEM.

The taxonomic position of *Hydnotrya cerebriformis* Harkn. in the genus *Hydnotrya* Berk. & Br. was questioned by Trappe (1979). He stated, "Because of their spore characters, however, they (the echinulate, globose-spored species) do not conform completely to the Helvellaceae. If future studies reveal different affinity, they may deserve generic separation." I became interested in this question when, three years ago, I examined some specimens deposited in **K**. Recently, when I was working on the Chinese hypogeous ascomycetes, I came across this problem again due to the occurrence of *Hydnotrya cerebriformis* in China. For direct comparison of the Chinese material with the type specimen, and clarifying this problem, the type and other specimens were borrowed from **BPI** and the Mycological Herbarium of Shanxi University (**MHSU**), and their morphology, SEM of ascospore ornamentation, number of nuclei in ascospores, and taxonomy were studied. This paper presents the results.

MATERIAL AND METHODS

Material used for this study was from the following herbaria: **BPI**, **K**, **MHSU**. For SEM, part of the hymenium of a dried ascoma was rehydrated on a clean glass slide, then stuck on to an adhesive layer on a small clean cover slip, then coated with gold and observed using an Hitachi S570 SEM.

* Present address: CAB International, Wallingford, Oxon., OX10 8DE, UK

The number of nuclei in ascospores was studied using the HCl-Giemsa staining technique based on Zhang & Minter (1989a, b) with minor modifications. Part of the hymenium taken from a dried ascoma was mounted in 5% KOH, squashed to release ascospores from the asci and protoplasts from the broken walls, then spread on clean microscope slides and air-dried. The preparations were fixed in Carnoy's solution for 15 minutes, rinsed three times in 95% ethyl alcohol, then kept in 70% ethyll alcohol for 1 week. Preparations were then immersed in 1N HCl for 5 minutes at room temperature, hydrolysed in 1N HCl at 62-64°C for 12 minutes, rinsed three times in distilled water, then in phosphate buffer (pH 7), stained with Giemsa solution (1 part Giemsa stock solution diluted with 10 parts phosphate buffer, pH 7) for 2 hours, and then rinsed in phosphate buffer and distilled water, air dried, then mounted in water and immediately examined under the light microscope.

RESULTS

Circumscription of the species

The following description was based on my type study and examination of other collections. Because the type specimen is composed of a single ascoma, it obviously provides limited information. So the description is a combination of features of the type and other material available for the present study. The colour and size of fresh ascomata are taken from Harkness (1899) and Tao (1988), for I have not seen any fresh material.

HYDNOTRYA CEREBRIFORMIS Harkn., *Proc. Calif. Acad. Sci.* III, **1**: 266 (1899); emend. nov. Figs 1-15

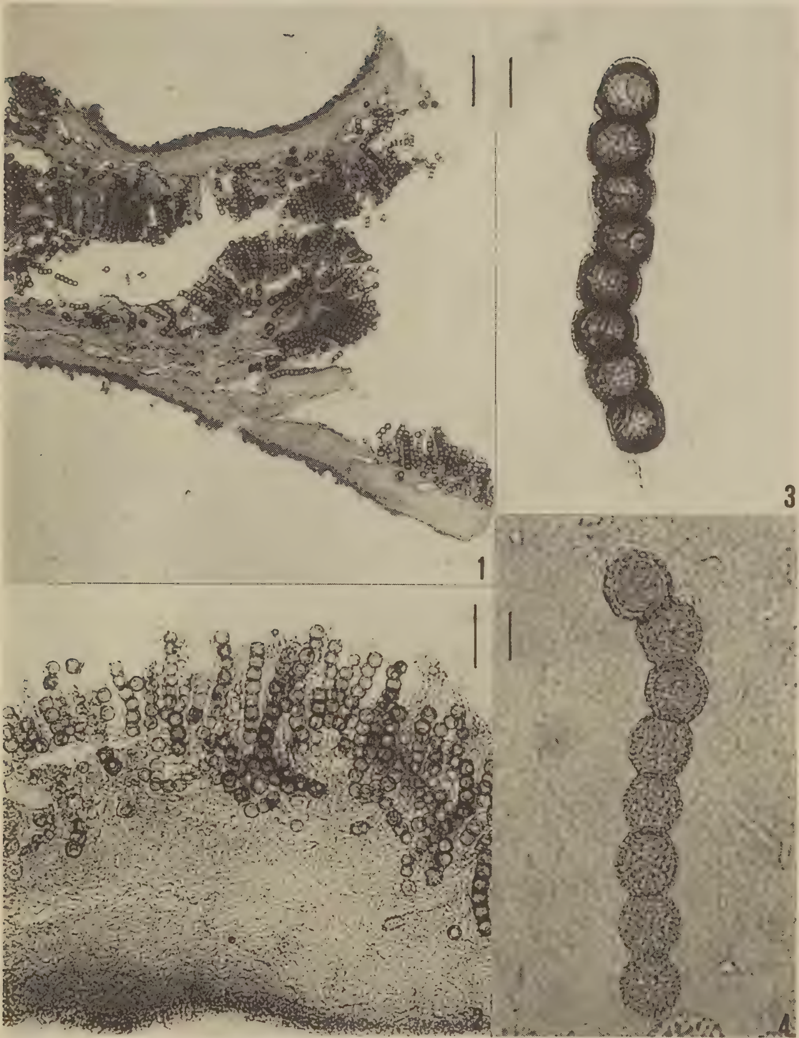
Ascomata subglobose to irregular, cerebriform, often coarsely lobed, much infolded and convoluted, yellowish to pale brown when young, salmon-colour to dull reddish brown or brown when old, 0.5-5 cm diam or in the largest dimension, with orifices to the interior, surface smooth to slightly scurfy.

Peridium 250-450 μm thick, of two layers; the outer layer very thin, with cells more or less isodiametric to angular, yellowish to pale brown, 8-32 (-40) μm diam, with walls slightly thickened, forming a textura angularis; the inner layer with cells filamentous but often inflated, yellowish to pale brown, 5-15 μm diam, forming a textura intricata.

Gleba nearly concolourous with the surface but with hymenia paler, with several labyrinthine small chambers or canals opening to the exterior at several points between folds, lined with hymenia, often anastomosed due to contact of opposed paraphyses.

Asci cylindrical, 180-300 x 28-40 μm, with thin walls, 2-layered, with 8 uniseriate spores, borne among paraphyses in a hymenium. Paraphyses filiform, hyaline, septate, longer than asci, slightly swollen at apex.

Ascospores globose but sometimes becoming flattened to subcubical due to crowding in the ascus, pale brown to brown, 25-40 μm including ornamentation, appearing echinulate, buried in a gelatinous matrix, 4-nucleate.



Figs 1-4. *Hydnotrya cerebriformis* (1-3, Type; 4, A.H. Smith 66207). 1. Section of ascoma, showing glebal chamber lined with hymenium (bar = 200 μm). 2. Part of hymenium (bar = 100 μm). 3-4. Asci and spores (3 in lactophenol with cotton blue) (bar = 20 μm).

SPECIMENS EXAMINED: USA: California: Nevada Co., Donner Lake, among fir trees, H.W. Harkness 37 (Type, **BPI**); Idaho: under spruce, A.H. Smith 60171, 17.viii.1958 (**K**); Valley Co, Squaw Meadows, under spruce, A.H. Smith 60274, 18.viii.1958 (**BPI**); under spruce, A.H. Smith 66207, 26.viii.1962 (**K**); Idaho Co, Near Florence, A.H. Smith 69290, 13.viii.1964 (**BPI**); L.E. Hawker, 22.viii.1962 (**K**); Alaska: Ptarmigan Crek Campground, under spruce, Well-Kempton, 9.ix.1965 (**BPI**, **K**). SWITZERLAND: Zugebury, under log, D.A. Reid, 11.viii.1974 (**K**, as "*Hydnotrya soehneri* Svrcek"). CHINA: Shanxi: Ningwu Co, Mt Guan-chen shan, hypogeous under *Lonicera chrysantha* Turc. with *Larix* sp. nearby, Tao Kai & Cao Jin-zhong, 11.viii.1987 (**MHSU** 1442, 1445); Cao Jin-zhong & Tai Kai, 7.viii.1987 (**MHSU** 1444); Mt Guan-di shan, hypogeous under *Larix principis-rupprechtii* Mayr., Shangguan Tieliang, vii.1987 (**MHSU** 1446); Xinjiang: Qitai Co., hypogeous in a forest, Fan Ju-lan, 17.vii.1981 (**MHSU** 1447). The specimens in **K** were examined during my visit to the Herbarium of Royal Botanic Gardens, Kew, England, in 1987-1988.

Ascus apex structure

Using the compound microscope, a weak zone at the top of many young asci was clearly visible (Figs 5-7). When mounted in water, covered with a coverslip and then slightly squashed, cytoplasm or young spores were squeezed out from the top which was often open, with a well-differentiated apical ring like an operculum (Figs 5-6), occasionally split (Fig. 6).

Ascospore walls and ornamentation

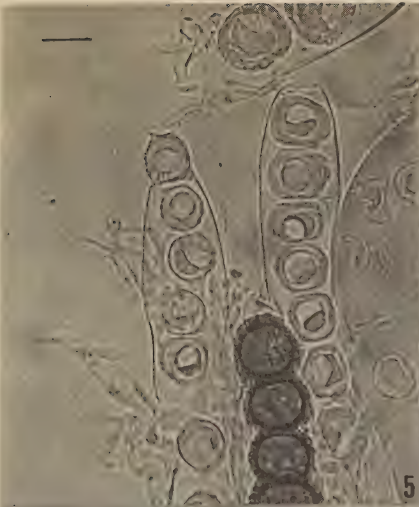
The 4-layered spore walls were clearly distinguishable especially when mounted in lactophenol with cotton blue (Figs 8-9). The inner wall group is composed of 3 walls: 2 walls stained deeper with 1 nearly hyaline wall between (Fig. 8). The epispore is well differentiated and appears echinulate buried in a gelatinous matrix (Figs 8-9).

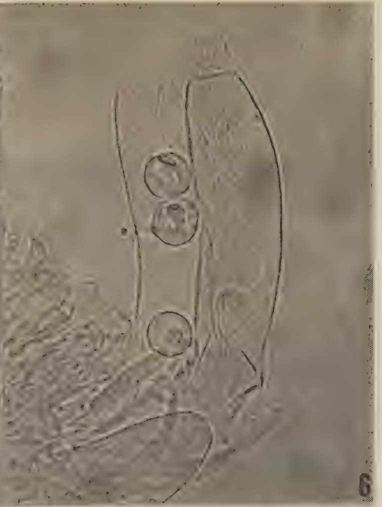
Under the light microscope ascospores appear ornamented with small spines (Figs 8-9). That is what Harkness (1899) and Gilkey (1954) described. But under SEM, spines were not visible, and the surface is obviously covered with gelatinous material (Figs 12-15). In some spores the gelatinous material was broken down, and then the minute spines which often join together were visible (Figs 14-15).

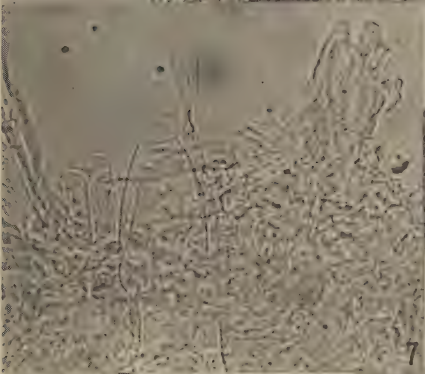
Ascospore nuclei

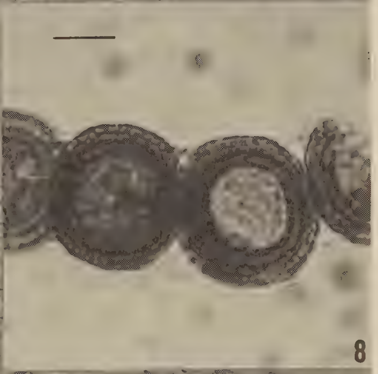
Three preparations from the type specimen and specimens from Alaska and **MHSU** 1445 were stained, but only one (**MHSU** 1445) gave good results. Mature ascospores are 4-nucleate (Figs 10-11). The nuclei are pyriform, kidney-shaped, or ellipsoidal to subglobose, mostly about 2 μm diam in the largest dimension. In some young spores, 2 or 3 nuclei were observed, in this case, the nuclei were twice as large and were tending to divide. Nuclei in intact spores were not visible.

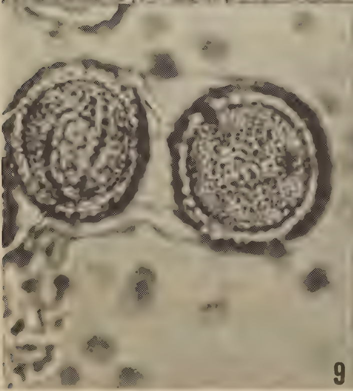
Figs 5-11. *Hydnotrya cerebriformis* (5-7, A.H. Smith 66207; 7-9, type; 10-11, **MHSU** 1445). 5-7. Young asci, showing apical openings (bar = 20 μm). 8. Ascospores in lactophenol with cotton blue, note spore walls. 9. Surface view of ascospores in lactophenol with cotton blue, showing ornamentation. 10-11. Tetranucleate protoplasts of ascospores. (8-11, bar = 10 μm).

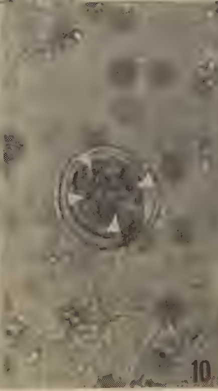

5

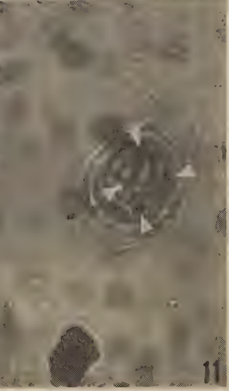

6

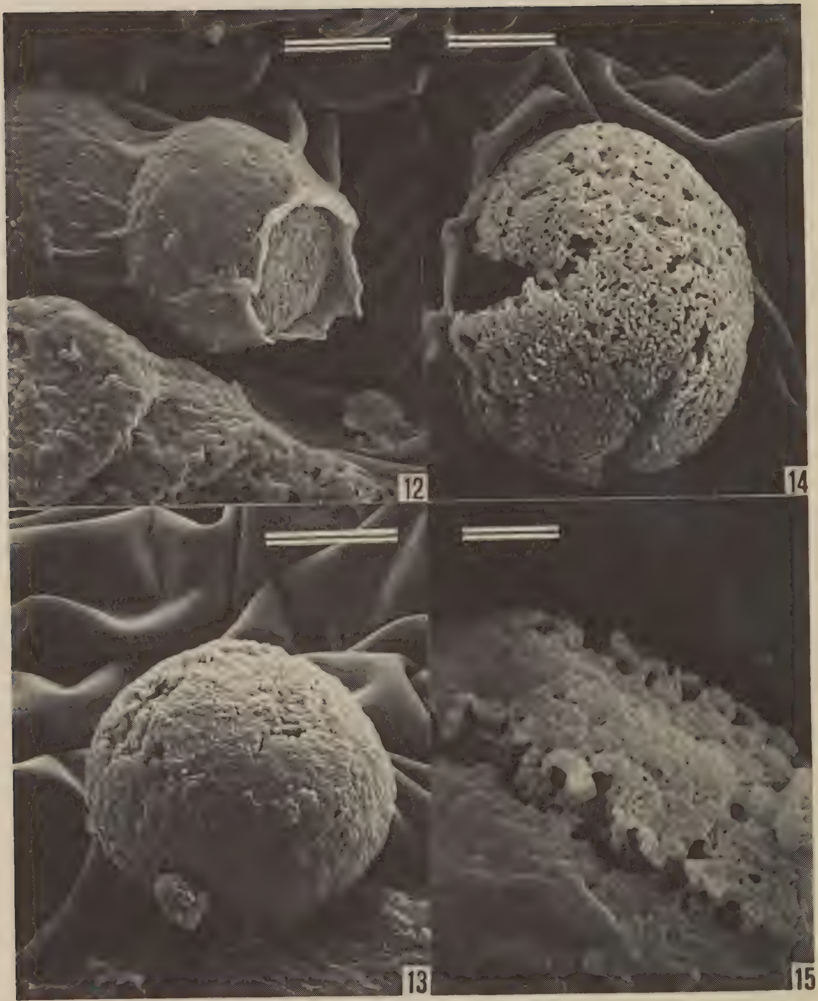

7


8


9


10


11



Figs 12-15. *Hydnotrya cerebriformis* (Type, SEM). 12. Ascospores in the ascus. 13-14. Surface view of ascospores (12-14, bar = 10 μm). 15. Detail of ornamentation, note gelatinous material covering on the surface and anastomosed spines beneath (bar = 3 μm).

DISCUSSION

Taxonomic position of Hydnotrya cerebriformis

As indicated at the beginning of this paper, the taxonomic position of the species in *Hydnotrya* was questioned by Trappe (1979). The results of the present study revealed, however, that except for ascospore ornamentation, all other features such as gross morphology, peridial anatomy and the number of nuclei in ascospores agree well with the concept of the genus *Hydnotrya*. *H. cerebriformis* shares many similarities to some species in the genus on one hand, and to the others on the other hand (Trappe, 1979).

The significance of ascospore ornamentation in taxonomy of hypogeous ascomycetes was discussed by Zhang & Minter (1989b). Generally, ascospore ornamentation is a critical character in species separation, and an important character at generic level in a given group as well, but it should be considered with other features. The ascospore ornamentation of *H. cerebriformis* is indeed very different from other species of the genus, but the other features are very similar. If we separate *H. cerebriformis* from the genus solely based on ascospore ornamentation, the generic concept appears too narrow. In fact, there often exist two or more totally different types of ascospore ornamentation in both epigeous and hypogeous members of the Pezizales, for example, in *Peziza* Dill. ex Bull. and *Tuber* Mich.: Fr. (Korf, 1972; Trappe, 1979).

The number of nuclei in ascospores is regarded as a key feature in indicating phylogenetic relationship in the Pezizales (Berthet, 1964; Korf, 1973; Zhang & Minter, 1989a, b). The ascospores of *H. cerebriformis* are 4-nucleate (Figs 10-11), the same as those of *H. tulasnei* Berk. & Br. and *H. michaelis* (Fischer) Trappe (Berthet, 1982; Donadini, 1986). Tetranucleate ascospores are characteristic of the Helvellaceae (Korf, 1972) and the placement of *Hydnotrya* in the family was confirmed by studies on this feature of the members of the genus (Berthet, 1982; Donadini, 1986). It is clear that *H. cerebriformis* does have a phylogenetic affinity with the other species of *Hydnotrya*, and does conform to the concept of the Helvellaceae.

From the above discussion, I believe that the current concept of *Hydnotrya* is acceptable and that *H. cerebriformis* should be retained in the genus.

Ascus apical opening: a trace structure of an operculum

Most of young asci of *H. cerebriformis* have a weak zone on the top which is readily broken off. The apical opening seems well differentiated from the rest of ascus (Figs 5-7) and it is very similar to the operculum of the epigeous Pezizales but has lost its function in spore release. This nonfunctional opening appears to be a trace structure of an operculum present in their ancestors, and provides a link between operculate asci in the epigeous helvellaceous members and asci without any openings in the hypogeous members.

Ascospore ornamentation

The spore ornamentation of *H. cerebriformis* is very peculiar, and is fundamentally different from the other species (Figs 8-9, 12-15). I carefully examined ascospores from all specimens and I found that gelatinous material is present in all and covers the echinulate epispore, which was clearly visible when mounted in lactopnenol with cotton blue. Observations using SEM confirmed the existence of gelatinous material covering the epispore. The type specimen is more than 100-years old and the gelatinous material is still present. This probably indicates that ascospores are not fully mature, even though they are dark-coloured; or the gelatinous material is persistent.

This study was partly supported by the National Natural Science Foundation, China. The author is grateful to the directors of the herbaria **BPI**, **K** and **MHSU** for the loan of the specimens. Mr. Dong Guang-jun and Ms Yun Nan-cui are acknowledged for their assistance in SEM observation and printing the photographs. Prof. R.P. Korf, Cornell University, Ithaca, New York, USA, is deeply appreciated for reviewing the manuscript.

REFERENCES

Berthet, P. (1964). Essai Biotaxinomique sur les Discomycètes. Joanny Lorge, Lyon.

Berthet, P. (1982). Sur la position taxonomique d'*Hydnotrya michaelis* (Fischer) Trappe (= *Geoporella michaelis* (Fischer) Soehner) (Ascomycètes). *Bull. Soc. Mycol. France* **98**: 74-79.

Donadini, J.C. (1986). *Hydnotrya tulasnei* Berk. & Br., histologie, cytologie, scanning. Sa place dans les Helvellacées. *Documents Mycol.* **17** (65): 19-33.

Gilkey, H.M. (1954). Tuberales. *North Am. Flora* 2, **1**: 1-36.

Harkness, H.W. (1899). Californian hypogeous fungi. *Proc. Calif. Acad. Sci.* 3, **1**: 241-292.

Korf, R.P. (1972). Synoptic key to the genera of Pezizales. *Mycologia* **64**: 936-994.

Korf, R.P. (1973). Discomycetes and Tuberales. In: *The Fungi* (eds. G.C. Ainsworth, F.K. Sparrow & A.S. Sussman), vol.**IVA**, pp. 249-319. Academic Press, London.

Tao, K. (1988). Taxonomic study on hypogeous fungi of China. M.Sc. Thesis, Shanxi University, Taiyuan.

Trappe, J.M. (1979). Orders, families and genera of hypogeous Ascomycotina (truffles and their relatives). *Mycotaxon* **9**: 297-340.

Zhang, B.C. & Minter, D.W. (1989a). Morphology, cytology and taxonomy of *Choiromyces gangliiformis* (Pezizales). *Mycol. Res.* **92**: 91-94.

Zhang, B.C. & Minter, D.W. (1989b). *Gymnohydnotrya*: a new hypogeous ascomycete genus from Australia. *Mycol. Res.* **92**: 192-198.

MYCOTAXON

Volume XLII, pp. 163-169 October-December 1991

A NEW SPECIES IN THE LICHEN GENUS PARMELIA (PARMELIACEAE, ASCOMYCOTINA), FROM THE BLOUBERG, NORTHERN TRANSVAAL, SOUTH AFRICA, WITH FURTHER NOTES ON SOUTHERN AFRICAN LICHENS

FRANKLIN A. BRUSSE

National Botanical Institute, Private Bag X101, Pretoria. 0001 SOUTH AFRICA

ABSTRACT

A new species in the lichen genus *Parmelia* (Parmeliaceae, Ascomycotina) is described from the Blouberg, South Africa. The new species is: *Parmelia ectypa* Brusse. Nine new records for southern Africa are presented and four previously reported records are deleted.

INTRODUCTION

The Blouberg Mountains are a cluster of mountains and foothills in the north-western Transvaal, South Africa, lying at 23° south and 29° east. The mountains are composed mainly of sedimentary sandstone of the Waterberg Series and lie to the west of the Soutpansberg Range, also composed of sediments in the same Waterberg Series. Despite being further west and therefore drier than the Soutpansberg, saxicolous lichens are very abundant here, with the southern aspect of many boulders being completely covered by a mosaic of crustose lichens, particularly on the southern and eastern slopes towards the upper reaches of the highest mountain. The highest mountain, called Ga-Monnaasenamoriri, is just over 2 000 m high.

A new species of the foliose lichen genus *Parmelia* is herein described from this locality, and in addition, the occurrence of several interesting species is recorded. The small grey *Parmelia (Paraparmelia) mongaensis* Elix (F. Brusse 5812) originally described from Australia, is very abundant at this locality on the east slope, near or in temporary seepages on sandstone. This lichen has previously been reported for the Transvaal from Magoeba's Kloof, a much wetter locality to the south-east (Nash & Elix 1987). *Parmelia (Flavoparmelia) pachydactyla* Hale, a new record for the Flora of southern Africa area, is cited in full below. This lichen is abundant on the NE face of a single boulder on a fairly gentle NW slope, but does not seem to be of general occurrence here. Other of the more interesting occurrences on rock were *P. (Paraparmelia) rodriguesiana* Hue (F. Brusse 5803), *P. (Hypotrachyna) erythrodes* (F. Brusse 5802), *P. (Hypotrachyna) bahiana* Nyl., *P. (Hypotrachyna) scytophylla* Kurok., *P. (Bulbothrix) decurtata* Kurok., *P.*

(Xanthoparmelia) hypoprotocetrarica Kurok. & Elix (F. Brusse 5816) and *Xanthoparmelia shebaiensis* Nash & Elix.

In general, the *Parmelia* flora resembles that of the eastern Transvaal Drakensberg Mountains more closely than that of the Soutpansberg. This is unanticipated, in view of the fact that the Blouberg lie further west than the Soutpansberg and therefore would be expected to be drier and have a less prolific lichen flora.

NEW SPECIES

Parmelia ectypa Brusse, *sp. nov.* Fig. 1

Thallus parvofoliosus, saxicola, usque ad 3 cm diametro, sat adnatus. *Lobi* elongati, 0.3 - 1.5 mm lati, 55 - 160 µm crassi; margines ciliati, ciliis atris, simplicibus. *Thallus superne* cinerascens, nitidus, epicortice poroso, isidiatus, isidiis cylindricis (fig. 2), saepe simplicibus, sed interdum nonnihil ramosis, interdum lobulascentibus et procumbentibus, apicibus atris, eciliatis, circa 50 µm crassis et usque ad 1 mm longis. *Cortex superior* 9 - 11 µm crassus, paraplectenchymatus. *Stratum gonidiale* 15 - 30 µm crassum, algis *Trebouxiis*, 4.5 - 12.5 µm diametris. *Medulla* albida, 30 - 110 µm crassa. *Cortex inferior* 4.5 - 9.0 µm crassus. *Thallus inferne* piceus, sat rhizinatus. *Rhizinae* plerumque simplices, interdum pauciramosae, 35 - 70 µm crassae. *Apothecia* et *pycnidia* non visa. *Thallus* atranorinum, acidum gyrophoricum, et acidum 5-O-methylhiascicum, et pigmentum flavum ignotum continens.

TYPUS: SOUTH AFRICA, TRANSVAAL - **2328** (Baltimore): Blouberg Mountains. Farm Beauley 260 LR. SE side of Ga-Monnaasenamoriri Mountain (the highest peak in the Blouberg). On S sides of Waterberg Sandstone boulders on SE slope in short river gorge. Alt. 1800 m (-**BB**). *F. Brusse 5810*, 6. xii. 1990 (**PRE**, holo-; **ANUC**, **BM**, **LD**, **S**, **UPS**, **US**, iso-). Figurae 1 et 2.

Thallus small foliose, saxicolous, up to 3 cm across, moderately adnate. *Lobes* elongate, 0.3 - 1.5 mm broad, 55 - 160 µm thick, margins ciliate, cilia black, simple. *Upper surface* greyish, with a slight yellow tint, glossy; epicortex pored; isidiate; isidia cylindrical (fig. 2), frequently simple, but sometimes somewhat branched, sometimes becoming lobulate and procumbent, tips black, non-ciliate, about 50 µm thick and up to 1 mm long. *Upper cortex* 9 - 11 µm thick, paraplectenchymatous. *Algal layer* 15 - 30 µm thick; algae *Trebouxia*, 4.5 - 12.5 µm diam. *Medulla* whitish, 30 - 110 µm thick. *Lower cortex* 4.5 - 9.0 µm thick. *Lower surface* black, moderately rhizinate. *Rhizines* often simple, sometimes sparingly branched, 35 - 70 µm thick. *Apothecia* and *pycnidia* not seen. *Chemistry*: atranorin/chloroatranorin, gyrophoric and 5-O-methylhiascic acids, and unknown yellow pigment present.

This new species is similar to *Parmelia (Parmelinopsis) minarum* Vain. both in morphology and chemistry, but is much smaller in size and is saxicolous. *P. minarum* is mainly corticolous, but will also grow on rock where plant litter can accumulate under it. The lobes of *P. ectypa* are 0.3 - 1.5 mm wide, whereas those of

P. minarum are 1 - 3 mm wide (Hale 1976b, Swinscow & Krog 1988). The isidia of *P. ectypa* are black-tipped whilst those of *P. minarum* are not. An analogous situation exists in the species pair *Parmelia (Bulbothrix) decurtata* Kurok. - *P. (Bulbothrix) tabacina* Mont. & v.d. Bosch, except in the latter case the two species are of comparable size (Hale 1976a).

Parmelia ectypa is also similar to *Parmelia (Parmelinopsis) horrescens* Tayl., but the latter is, again, essentially a corticolous lichen, and has ciliate isidia. The isidia of *P. ectypa* are always non-ciliate. The overall size of the lobes of these two species is similar, with those of *P. ectypa* being 0.3 - 1.5 mm wide, and those of *P. horrescens* being 0.5 - 2.0 mm wide (Hale 1976b). Nevertheless, *P. ectypa* also lacks significant quantities of 4,5-di-O-methylhiascic acid, which is present in *P. horrescens*, in addition to the gyrophoric and 5-O-methylhiascic acid present in both these species (Elix, Jayanthi & Leznoff 1981).

There is no true parent morph of *Parmelia ectypa*, but *Parmelinopsis neodamaziana* (Elix & Johnston) Elix & Hale comes close to it (Elix & Johnston 1986), being small and containing gyrophoric acid. However, this species has a more elaborate secondary metabolite profile, with gyrophoric, 2,4-di-O-methylgyrophoric, umbilicaric, 5-O-methylhiascic, 2-O-methylhiascic (tr.) and 2,4,5-tri-O-methylhiascic acids in the medulla (Elix, Jayanthi & Wardlaw 1989).

The larger, *Parmelia damaziana* Zahlbr. does not appear to be the parent morph of *P. ectypa*, as it is essentially corticolous and contains 3-methoxy-2,4-di-O-methylgyrophoric acid together with gyrophoric and 5-O-methylhiascic acids in the medulla.

It is interesting to note that the upper cortex of *P. ectypa* is paraplectenchymatous and not anticlinally prosoplectenchymatous (sometimes termed palisade plectenchyma) as is common in *Parmelia* in the broad sense. Nevertheless, a paraplectenchymatous cortex structure may be common in the species previously assigned to *Parmelina sensu lat*. (Hale 1976b), since all the scanning electron micrographs of upper cortices of this group published by Hale (1976b) exhibit paraplectenchymatous rather than palisade plectenchymatous upper cortices. This includes two species presently placed in *Myelochroa* (Asahina) Elix & Hale and one species which was retained in *Parmelina* Hale by Elix & Hale (1987).

At present, this new species is known only from the Blouberg, in the northern Transvaal, South Africa.

NEW RECORDS AND CORRECTIONS

Actinoplaca strigulacea Müll. Arg.

SOUTH AFRICA, TRANSKEI - **3228** (Butterworth): Dwesa Nature Reserve. About 0.5 km from campsite on road to mPume gate. In understorey vegetation of coastal forest. Alt. 40 m (-**BD**). *F. Brusse 5634*, 9. i. 1990 (on living fronds of the cycad *Encephalartos villosus* Lem.; **B, BM, LD, PRE, S, UPS**). Conf. R. Santesson 1991.

Bacidina pallidocarnea (Müll. Arg.) Vezda

SOUTH AFRICA, TRANSKEI - **3228** (Butterworth): Dwesa Nature Reserve. About 0.5 km from campsite on road to mPume gate. In understorey vegetation of coastal forest. Alt. 40 m (-**BD**). *F. Brusse 5867*, 5. i. 1991 (on living fronds of the cycad *Encephalartos villosus* Lem.; **BM**, **PRE**).

Dimerella zonata Müll. Arg.

Brusse (1988) cited this species as a new record for southern Africa. The determination has since been checked, and found to be epiphyllous *Dimerella lutea* (Dicks.) Trevis. This record is therefore hereby deleted.

Heterodermia erinacea (Ach.) W. Weber

This species was cited as a new record for southern Africa by Brusse (1988) but the determination is erroneous, and the material represents an unknown taxon superficially resembling *Heterodermia comosa* (Eschw.) Follm. & Rédon. *Heterodermia erinacea* is therefore hereby deleted from the Flora of southern Africa.

Mazosia melanophthalma (Müll. Arg.) R. Sant.

SOUTH AFRICA, TRANSKEI - **3228** (Butterworth): Dwesa Nature Reserve. 4 km from campsite on road to mBashe. 10 - 50 m beyond nGoma river bridge. In understorey vegetation of coastal forest. Alt. 20 m (-**BD**). *F. Brusse 5667* (on leaves of *Cassipourea gummiflua* Tul.; **BM**, **PRE**); *5680* (on the peculiar peltate leaves of *Heywoodia lucens* Sim saplings; **BM**, **PRE**); *5699* (on leaves of *Suregada procera* (Prain) Croizat; **BM**, **PRE**) & *5710* (on leaves of *Buxus natalensis* (Oliv.) Hutch.; **BM**, **LD**, **PRE**), 10. i. 1990.

Parmelia (Flavoparmelia) pachydactyla Hale

SOUTH AFRICA, TRANSVAAL - **2328** (Baltimore): Blouberg Mountains. Farm Beauley 260 LR. On NE face of Waterberg Sandstone boulder, on fairly gentle NW slope, in mountainous terrain. Common on one boulder, otherwise not seen. Alt. 1800 m (-**BB**). *F. Brusse 5795*, 3. xii. 1990 (**ANUC**, **B**, **BM**, **C**, **CBG**, **COLO**, **CTES**, **LD**, **NDA**, **NY**, **PRE**, **S**, **UC**, **UPS**, **US**).

Parmelia usambarensis Stnr. & Zahlbr.

This species was cited as a new record for southern Africa by Brusse (1988), but this specimen is the widespread and common tropical and subtropical Old World species *Parmelia (Parmelinella) wallichiana* Tayl., and is hereby deleted.

Parmelia (Rimelia) commensurata Hale

SOUTH AFRICA, TRANSVAAL - **2430** (Pilgrim's Rest): Eastern Transvaal Drakensberg mountains. 6 km from Pilgrim's Rest to Graskop. On tree trunk (-**DD**). *C.H. Stirton 7034*, 22. ii. 1977 (**PRE**).

Pyrrhospora sanguinolenta (Kremp.) Rambold & Hafelln.

SOUTH AFRICA, TRANSVAAL - **2328** (Baltimore): Blouberg Mountains. Farm Beauley 260 LR. On Waterberg Sandstone boulders near SE base of cliffs, on steep SE slope of Ga-Monnaasenamoriri. Alt. 1800 m (-**BB**). *F. Brusse 5801*, 5. xii. 1990 (**BM**, **PRE**). **2329** (Pietersburg): Soutpansberg, approximately 50 km W of Louis Trichardt. Summit of mountain range on the farm Ottosdal. Rocky quartzite and sandstone terrain on S edge of summit. On rock. Alt. 1430 m (-**AB**). *F. Brusse 4438*, 13. i. 1986 (**PRE**). **2430** (Pilgrim's Rest): Mount Sheba near Pilgrim's Rest. Scattered sandstone boulders on S slope, near summit of mountain. On S side of boulder. Alt. 1850 m (-**DC**). *F. Brusse 4465*, 15. i. 1986 (**PRE**).

NATAL - **2829** (Harrismith): Cathedral Peak Nature Reserve, near Rainbow Valley/Doreen Falls fork at Cathedral Peak hotel. On Clarens (Cave) Sandstone boulder near stream, in partial shade. Alt. 1680 m (-**CC**). *F. Brusse 4546*, 22. i. 1986 (**COLO, PRE**).

This species has recently been reported from Australia (Rambold 1989), but it is also common in the eastern part of southern Africa as the above records indicate, and is thus also a new record for the African continent.

Strigula nitidula Mont.

SOUTH AFRICA, TRANSKEI - **3228** (Butterworth): Dwesa Nature Reserve. 4 km from campsite on road to mBashe. 10 - 50 m beyond nGoma river bridge. In understorey vegetation of coastal forest. Alt. 20 m (-**BD**). *F. Brusse 5855*, 4. i. 1991 (on *Buxus natalensis* (Oliv.) Hutch. leaves; **BM, LD, PRE**).

Brusse (1991) cited *Phylloporis phyllogena* (Müll. Arg.) Clem. (as *Porina phyllogena* Müll. Arg.) from this locality (F. Brusse 5706), but this determination is incorrect and the material represents *Strigula nitidula* Mont. However, the above specimens are better developed and this new material is used to cite the species. *Phylloporis phyllogena* (Müll. Arg.) Clem. is therefore still unknown from the flora of southern Africa.

Tapellaria epiphylla (Müll. Arg.) R. Sant.

SOUTH AFRICA, TRANSKEI - **3228** (Butterworth): Dwesa Nature Reserve. 4 km from campsite on road to mBashe. 10 - 50 m beyond nGoma river bridge. In understorey vegetation of coastal forest. Alt. 20 m (-**BD**). *F. Brusse 5662* (on *Cassipourea gummiflua* Tul. leaves; **BM, PRE**), 10. i. 1990. Conf. R. Santesson 1991.

Thelotrema wightii (Tayl.) Nyl.

SOUTH AFRICA, TRANSKEI - **3228** (Butterworth): Dwesa Nature Reserve. 4 km from campsite on road to mBashe. 10 - 50 m beyond nGoma river bridge. On bark, low down on trunk of *Heywoodia lucens* Sim tree, in shade of coastal forest. Alt. 20 m (-**BD**). *F. Brusse 5850*, 4. i. 1991 (**BM, LD, PRE, UPS**).

ACKNOWLEDGEMENTS

The fieldwork in the Blouberg was generously supported by the South African Council for Scientific and Industrial Research's (CSIR), Foundation for Research Development (FDR) and the company Barlow Rand. The author is also grateful to Mr. Fanie Venter (Sovenga) for arranging the Blouberg Excursion. I am also thankful for the permission to collect on the Blouberg obtained from Chief Malabogo III, and to the Lebowa Nature Conservation Authorities for collecting permits. Thanks are extended to Dr. J.A. Elix (Canberra) for reviewing this manuscript and for determining the chemistry of some lichen specimens. I am also grateful to Mrs. A.J. Romanowski for preparing the photographs.

LITERATURE CITED

BRUSSE, F.A. 1988. Five New Species of *Parmelia* (Parmeliaceae, Lichenized Ascomycetes) from Southern Africa, With New Combinations and Notes, and New Lichen Records. *Mycotaxon* **31**: 533 - 555.

BRUSSE, F.A. 1991. Eight New Species in the Lichen Genus *Parmelia* (Parmeliaceae, Ascomycotina) from Southern Africa with Notes on Southern African Lichens. *Mycotaxon* **40**: 377 - 393.

ELIX, J.A. & HALE, M.E. 1987. *Canomaculina, Myelochroa*, *Parmelinella*, *Parmelinopsis* and *Parmotremopsis*, Five New Genera in the Parmeliaceae (Lichenized Ascomycotina). *Mycotaxon* **29**: 233 - 244.

ELIX, J.A., JAYANTHI, V.K. & LEZNOFF, C.C. 1981. 2,4-Di-O-methylgyrophoric Acid and 2,4,5-Tri-O-methylhiascic Acid. New Tridepsides from *Parmelia damaziana*. *Australian Journal of Chemistry* **34**: 1757 - 1761.

ELIX, J.A., JAYANTHI, V.K. & WARDLAW, J.H. 1989. 2-O-methylhiascic Acid, a New Tridepside in the Lichen *Parmelinopsis neodamaziana*. *Australian Journal of Chemistry* **42**: 1423 - 1426.

ELIX, J.A. & JOHNSTON, J. 1986. New Species of *Parmelina* (Lichenised Ascomycotina) from Australia and New Zealand. *Brunonia* **9**: 155 - 161.

HALE, M.E. 1976a. A Monograph of the Lichen Genus *Bulbothrix* Hale (Parmeliaceae). *Smithsonian Contributions to Botany* **32**: 1 - 29.

HALE, M.E. 1976b. A Monograph of the Lichen Genus *Parmelina* Hale (Parmeliaceae). *Smithsonian Contributions to Botany* **33**: 1 - 60.

NASH, T.H. & ELIX, J.A. 1987. New Species and New Reports in the Parmeliaceae (Lichenized Ascomycotina) from South Africa and Australia. *Mycotaxon* **29**: 467 - 476.

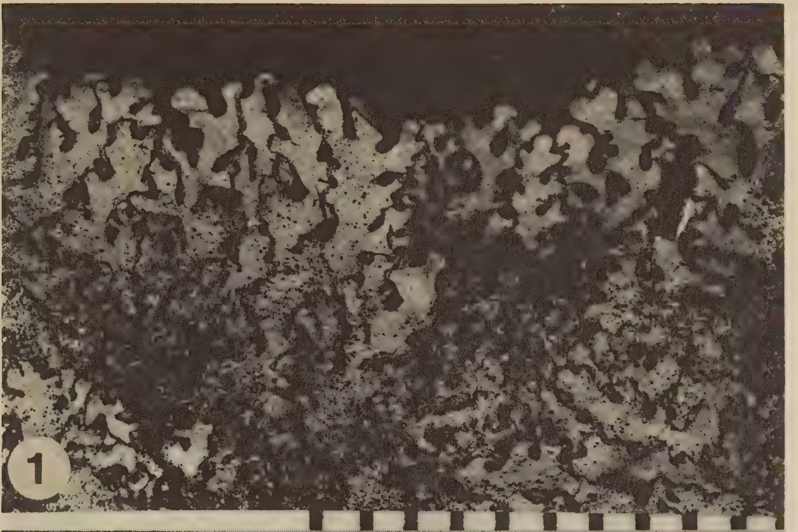
RAMBOLD, G. 1989. A Monograph of the Saxicolous Lecideoid Lichens of Australia (excl. Tasmania). *Bibliotheca Lichenologica* **34**: 140 - 144.

SWINSCOW, T.D.V. & KROG, H. 1988. *Macrolichens of East Africa*. London: British Museum (Natural History).

****

FIGURE 1. - *Parmelia ectypa* Brusse, habit photograph. *F. Brusse 5810*, holotype. Scale in mm.

FIGURE 2. - *Parmelia ectypa* Brusse, scanning electron micrograph of the isidia. *F. Brusse 5810*, holotype. Bar = 109 µm.



1

2

MYCOTAXON

Volume XLII, pp. 171-179 October-December 1991

GENOTYPIC PATTERNS OF SOME ITALIAN POPULATIONS OF THE *TUBER AESTIVUM- T. MESENTERICUM* COMPLEX.

GIOVANNI PACIONI and GIANCARLA POMPONI
Dipartimento di Scienze Ambientali, Universita', L'Aquila, Italy

Abstract: Some natural populations of *Tuber aestivum* and *T. mesentericum,* from various Italian localities, were checked by means of multilocus electrophresis on horizontal starch gel for nine loci. Departing from the traditional procedure, the taxonomic identification of the sporocarps was carried out making use of the following two characters: volume of spores and width of their reticulum. An outstanding genetic heterogeneity detected within the sample enabled us to single out 20 genotypic classes in all, ten ascribable to the species *Tuber aestivum* and ten to the species *T. mesentericum*. All of the sporocarps morphologically identified as *T. aestivum* came out to belong to genotypic classes other than those set apart for *T. mesentericum,* thus confirming the morphological data to be absolutely congruent with the genetic ones as to the separation of all the specimens analysed into two main groups. At present the existence within the samples, to be assigned to *T. aestivum* and *T. mesentericum* respectively, of several, at times quite different, genotypic classes is hard to explain, especially when the scanty insight into the reproductive mechanisms of the genus *Tuber* is taken into account. However, it is to emphasized that the genetic differentiation pointed out could be consequent on an ineffective and superficialinvestigation of the morphological characters; therefore we could be dealing with two distinct species complexes.

INTRODUCTION

Tuber aestivum Vitt. (Ascomycotina, Tuberales) presents a wide distribution, from Portugal to Turkey, from Norway to Algeria, including Great Britain. This truffle taxon constitutes a complex which has proved hitherto impervious to the morphological approach because of its great variability. Chevalier *et al.* (1978) gave an excellent account of the morphological variability of *Tuber aestivum*, including *T. uncinatum* Chat. as a subspecies. However they did not arrive at any practical conclusion in spite of the fact that they confined their study to French collections and did not consider the various morphological forms of *T. mesentericum* Vitt., a taxon which at times shows overlapping characters. During our preliminary studies (Pacioni & Pomponi, 1989), begun with a view to applying allozyme electrophoresis to solve genetic, systematic and phylogenetic questions regarding the genus *Tuber*, a great genetic stability was noted at the intraspecific level for the examined specimens of *Tuber melanosporum* Vitt. and *T. brumale* Vitt. On the other hand a great genetic heterogeneity was noted for the examined specimens of *T. aestivum* and *T. mesentericum*. When we proposed a biochemical key for a reliable identifica-

tion of some *Tuber* species (Pacioni & Pomponi, 1989), we considered just two populations of *T. aestivum* and *T. mesentericum* showing morphological characters very close to the original description by Vittadini (1831).
Palenzona *et al.* (1990) published a study on the genetic differentiation of ascocarps belonging to different species of the genus *Tuber* from different Italian geographical origin (Latium, Marche, Piedmont). Their results confirmed our previous ones and documented a clear genetic differentiation among the different species of the examined *Tuber* species. However they claimed that their results showed a great genetic homogenity, without any genotypic differentiation at the intraspecific level in the examined specimens of *Tuber aestivum* as well as of the others, included *T. mesentericum*. That is, in their analyses the electrophoretic patterns of *Tuber aestivum* were selected as control.
At present we can report evidence of the genotipic variability presented in several Italian populations of the species belonging to the taxa *Tuber aestivum* and *T. mesentericum* and record the genotypic classes found.

MATERIALS AND METHODS

A total of 56 specimens of the two species were collected in the following sites, where the progressive numbers in bold type will designate collection sites:
A-Tuber aestivum: **1**) Liguria, GE, Monte Penice, *Carpinus* and *Corylus* mixed forest, 30 Sept. 1988, *leg.* D. Bigioni, 2 sporocarps under two distinct trees; **2**) Abruzzo, AQ, Tagliacozzo,Poggio Filippo, beneath a *Quercus pubescens* Willd., 22 Feb. 1988, *leg.* C. Visca, 1 sporocarp; **3**) Abruzzo, AQ, Cappadocia, Pian delle Scagne, 4 Feb. 1988, beech forest, 1 sporocarp; **4**) Abruzzo, AQ, Tagliacozzo, Sorbo, oak forest, 8 Aug. 1988, seven sporocarps under 3 distinct trees; **5**) Abruzzo, AQ, Avezzano, Cese, under a *Q. pubescens*, 8 Aug. 1988, 2 sporocarps; **6**) Abruzzo, AQ,Magliano, Ruscella, oak forest, 8 Aug. 1988, three sporocarps beneath a group of trees; **7**) Abruzzo, AQ, Camarda, oak forest, 12 Sept.1988, 2 sporocarps under two distinct trees; **8**) Abruzzo, AQ, Pereto, Fonte la Teglia, oak forest, 23 Sept. 1988, 2 sporocarps under distinct trees; **9**) Abruzzo, TE, Valle Castellana, Mt. di Campli, beech forest, 11 Sept.1988, *leg.* O. Diomede, 3 sporocarps under distinct trees; **10**) Molise, CB, Castel del Giudice, under *Quercus cerris,* 9 Oct. 1988, 1 sporocarp ; **11**) Calabria, CS, Campo Tenese, Vivaio Pavone, beech and fir mixed forest, 12 Nov.1988, 3 sporocarps, including a 'variety' with very small warts and roundish spores; **12**) Calabria, CS, Saracena,Piano Navacco, beech forest, 12 Nov. 1988, 2 sporocarps under distinct trees.
M-Tuber mesentericum: **13**) Abruzzo, AQ, Cappadocia, Valico della Trinità, beech forest, 4 Febr. 1988, one sporocarp; **14**) Abruzzo, AQ, Cappadocia, Praticello,beneath a beech tree, 4 Febr. 1988, one sporocarp; **15**) Abruzzo, AQ ,Rocca di Botte, Praticello, beech forest, 1 Febr.1988, one sporocarp; **16**) Abruzzo,AQ, L'Aquila, Vasto di Assergi, *Carpinus* and *Corylus* mixed forest, 13 Sept. 1988, four sporocarps collected beneath separated trees; **17**) Abruzzo, AQ, Cappadocia, Prato Rotondo, beech forest, 4 Febr. 1988, two sporocarps under distinct trees; **18**) Abruzzo, AQ,Cappadocia, Pian delle Scagne, beech forest, 4 Febr.1988, one sporocarp "variety" with pleasant smell and smaller spores; **19**) Abruzzo, AQ, Filettino, beneath a *Quercus cerris* L, 22 Febr. 1988, *leg.* C. Visca, two sporocarps; **20**) Abruzzo, AQ, Camerata Nuova, beneath a beech tree, 23 Sept. 1988, four sporocarps; **21**) Calabria,CS, Campo Tenese, Vivaio Pavone, beech and fir mixed forest, 12 Nov.1988, three sporocarps; **22**) Calabria, CS, Saracena, Piano Navacco, beech forest, 12 Nov. 1988, eight sporocarps under distinct trees.

The specimens were collected either personally or by reliable cooperators from different localities of Italy. They were attributed to one or the other of the two species by the senior author on the basis of spore volume (Gross, 1987) and width of reticulate ornamentation of spores. These are two taxonomic criteria selected in alternative to the traditional but unsatisfactory ones. Thanks to them, some specimens appeared clearly distinct from the others, therefore were indicated as a variety. Every specimen has been preserved both deep-frozen for electrophoretic analyses and dried in the mycological herbarium of L'Aquila (AQUI) as a voucher. Horizontal starch gel electrophoresis was performed according to Pacioni & Pomponi (1989) for the following enzyme loci: hydroxybutyrrate dehydrogenase (*Hbdh*), malate dehydrogenase-1 and -2 (*Mdh-1*, *Mdh-2*), 6-phosphogluconate dehydrogenase (*6-Pgdh*), superoxidedismutase-1 (*Sod-1*), glutamate-oxalacetate transaminase (*Got*), phosphoglucomutase (*Pgm*), mannose phosphate isomerase (*Mpi*-1) and glucose phosphate isomerase (*Gpi*). Allozymes were named numerically according to their mobility asagainst the most common one in the reference species *Tuber melanosporum* Vitt. indicated as 100. This reference was mainteined inorder to compare the two taxa between them as well as with other taxa previously examined by means of multilocus electrophoresis. A 'genotipic class', as used in this context, is defined as a unit that can be distinguished by a series of electrophoretic phenotypes for the marker loci (Royse & May, 1982). Electrophoretic data were elaborated using the NTSYS-pc program by Rohlf (1987).

RESULTS

All loci presented patterns with one band except locus *Pgm* showing a pattern with three bands. All loci examined seem to be fixed in homozygosity and show a high activity. Locus *Hbdh* was monomorphic in all examined samples and the other loci showed different alleles. The electrophoretic patterns of all alleles of the species type *Tuber aestivum* and *T. mesentericum* at eight polymorphic loci are summarized in Table 1 and genotypes of the 22 populations are presented in Table 2. The observed phenotypes are shown in Fig.1 (zymogram). On the basis of the electrophoretic data, twenty genotipic classes were recognized among the 56 samples of *Tuber aestivum* and *T.mesentericum* studied. The genotypic classes, resumed in Tab.2, differ in a variable number of loci, from 1 to 7. In some collecting sites all samples were represented by a single genotypic class; in other the presence of different genotypic classes was noted as reported in Table 2. Because of the small size of the sample, data about the actual gene frequencies in each sampled population is uncertain. However, the genotypes of each individual are virtually known. Therefore a pairwise comparison of the similarity between individual genotypes can be used with a view to understanding something more about relatedness. The heterozigosity was not observed and this fact introduces an additional source of uncertainty. Studying the genotypes of *Agaricus bisporus* (Lange)Imbach, Kerrigan(1990) observed the same phenomenon and posed the problem of how the number of sampled loci should be extended in order to represent the overall genetic character of each sampled genome. The relatedness in *Tuber aestivum and T. mesentericum* was studied with a coefficient of genetic distance 'D' (Nei, 1972) between pairs of individuals genotypes. From the obtained matrix of the values of D, a dendrogram of phenetic similarities was produced by the UPGMA clustering procedure (Fig.2). The genotypic classes of *Tuber aestivum* are clearly separated from those gravitating around *Tuber mesentericum* at level of the value 0.959. Two clusters exist inside the genotypic classes of *Tuber aestivum* and four concerning *T. mesentericum*. This occurs at a value of similitude index of 0.32. The four clusters of *T. mesentericum* are distinct at a value of 0.591. The genotypic classes 'M9' and "M10" seem highly segregated from the two previous clusters of *T. mesentericum*.

DISCUSSION

The nature and extent of the genetic variation present with in aspecies, depends, first of all, on its mode of reproduction. In spite of a claimed explanation of this phenomenon (Dangeard, 1895/96; Grente & Delmas, 1974), the mode of reproduction of the genus *Tuber* is not yet correctly investigated and well understood (Pacioni & Lalli, 1990) and its systematics is very difficult because of the great morphological variability (Gross, 1987). Therefore the analysis of the genetic variability detected by means of electrophoretical data is complex . On the basis of the electrophoretic data , twenty genotipic classes, ten belonging to *T. mesentericum* and ten to *T. aestivum,* can be recognized. An interesting fact is that no one of the sporocarps attributed on a morphological basis to *T. aestivum* showed genotypic classes like the ones present in samples attributed to *T. mesentericum.* In addition, also those taxa recognized as 'varieties' are separated. In three areas, samples of both *T. aestivum* (populations 3, 11 and 12) and *T.mesentericum* (populations 18, 21 and 22) were collected mixed in the same place and the samples morphologically belonging to *T. aestivum* presented different genotypic classes not overlapping with the classes found in *T. mesentericum*. This means that the selected characters utilized for our determination can distinguish the two main taxa clearly. However it is possible that two distinct species complexes are involved.

Anyway it is very difficult to justify the detection of the high genetic variation present inside each type species. *Tuber aestivum* genotypes seem rather homogeneous. Only at level of 0.391 can two clusters be distinguished. However at this level four clusters are very clearly separated in the genotypes of *T. mesentericum*. The genotypes 'M9' and 'M10' appear still as distinct taxa. On the basis of its spore volume, the specimen representative of the genotype 'M10' shows the smallest values ever observed in this group of truffles. As regardas the specimen belonging to the genotype 'M9', the small flat warts and roundish spores can be its distinctive morphological characters. This result demonstrates a clear agreement between phenetic and genetic characters.

In conclusion, our results disagree completely with the assertions in Palenzona *et al.* (1990) as to the genetical homogenity of *Tuber aestivum.*

The presence of many genotypic classes inside the few populations of *Tuber aestivum* and *T. mesentericum* examined reflects the lack of a taxonomic characterization based on clear morphological characters. The few genotypic classes do not allow a biogeographical or ecological discussion. Long and more detailed research is needed to cope with an evolutionary approach to the problem. Our next research will be focused on the specific topic of the genetics of some populations in sympatric and allopatric situations.

AKNOWLEDGEMENTS: We are indebted to Prof. Edmondo Grilli for his assistance with the improvement of English. This study was supported in part by a M.U.R.S.T. grant.

REFERENCES

CHEVALIER, G., DESMAS, C., FROCHOT, H. & RIOUSSET, L. (1978). L'espece *Tuber aestivum* Vitt.:I.Definition. *Mushroom Science* **10**(1),957-975.

DANGEARD, P.A. (1985/86). La Truffle. Recherches sur son développement, sa structure, sa reproduction sexuelle. *Botaniste* **4/5**: 63-87. 73 GRENTE, J. & DELMAS, J. (1974). Perspectives pour une trufficulture moderne. Clermont-Ferrand, France: I.N.R.A.

GROSS, G., (1987). Zur den europaischen Sippen der Gattung *Tuber*. In '*Atlas der Pilze des Saarlandes,2: Nachweise, Okologie, Vorkommen und Beschreibungen*' (Derbsch H. & Schmitt J.A. eds), 79-99. Saarbrucken, Germany: Ed. Delattinia.

KERRIGAN, R.W. (1990). Evidence of genetic divergence in two populations of *Agaricus bisporus* . *Mycological Research* **94**, 721-733.

NEI, M. (1972). Genetic distance between populations. Amer. Nat. 106: 238-292.

PACIONI,G. & LALLI,G. (1990). Strategie adattative di alcuni *Tuber*. In '*Atti del Secondo Congresso Internazionale sul Tartufo*' (ed. M. Bencivenga & B. Granetti), pp. 403-408. Spoleto, Italy: Comunita' Montana dei Monti Martani e del Serano.

PACIONI, G. & POMPONI, G. (1989). Chemotaxonomy of some Italian species of *Tuber*. *Micologia e Vegetazione Mediterranea* **4**,63-72.

PALENZONA, M., BIOCCA,E., NASCETTI, G., FERRARA, A.M., MATTIUCCI S., D'AMELIO,S. & BALBO, T. (1990). Studi preliminari sulla tipizzazione genetica (sistemi gene-enzima) di specie del gener *Tuber*. In '*Atti del Secondo Congresso Internazionale sul Tartufo'* (ed. M. Bencivenga & B. Granetti), pp.53-58. Spoleto, Italy: Comunita' Montana dei Monti Martani e del Serano.

ROHLF, F.J. (1987). NTSYS-pc Numerical Taxonomy and Multivariate Analysis System. Setauker,NY,U.S.A.: Exeter Publishing.

ROYSE, D.Y. & MAY, B. (1982). Use of isoenzyme variation to identify genotypic classes of *Agaricus brunnescens*. *Mycologia* **74**, 93-102.

SNEATH, P.H.A. & SOKAL, R. (1973). Numerical taxonomy. San Francisco, U.S.A.: W.H. Freeman & Co.

VITTADINI, C. (1831). Monographia Tuberacearum. Milano,Italy : Felice Rusconi.

	Hbdh	*Mdh-1*	*Mdh-2*	*6Pgdh*	*Sod-1*	*Got*	*Pgm*	*Mpi-1*	*Gpi*
T.aestivum	100(29)	117(21) 127(8)	84(15) 93(9) 90(5)	94(2) 100(27)	85(29)	115(29)	90(29)	80(6) 85(15) 94(5) 100(3)	110(29)
T.mesentericum	100(27)	100(1) 106(26)	80(6) 93(19) 100(1) **(1)	100(27)	85(1) 100(26)	95(6) 100(1) 105(1) 115(17) 120(2)	90(10) 94(16) 100(1)	94(1) 100(25) 103(1)	100(1) 105(8) 110(18)

Table 1- Alleles observed in examined specimens of *Tuber aestivum* and *T. mesentericum*. (in brackets the number of samples with the allele in homozygosity) ** no enzimatic activity, presumed null allele

genotypic classes	*Hbdh*	*Mdh-1*	*Mdh-2*	*6Pgdh*	*Sod-1*	*Got*	*Pgm*	*Mpi-1*	*Gpi*	**site where genotype is present**
A1(5)	**100/100**	**127/127**	**90/90**	**100/100**	**85/85**	**115/115**	**90/90**	**94/94**	**110/110**	**11-12**
A2(3)	**100/100**	**117/117**	**93/93**	**100/100**	**85/85**	**115/115**	**90/90**	**80/80**	**110/110**	**1-2-10**
A3(2)	**100/100**	**117/117**	**93/93**	**100/100**	**85/85**	**115/115**	**90/90**	**100/100**	**110/110**	**9**
A4(4)	**100/100**	**117/117**	**93/93**	**100/100**	**85/85**	**115/115**	**90/90**	**85/85**	**110/110**	**4-6**
A5(1)	**100/100**	**117/117**	**84/84**	**100/100**	**85/85**	**115/115**	**90/90**	**80/80**	**110/110**	**1**
A6(2)	**100/100**	**127/127**	**84/84**	**100/100**	**85/85**	**115/115**	**90/90**	**80/80**	**110/110**	**8**
A7(1)	**100/100**	**127/127**	**84/84**	**100/100**	**85/85**	**115/115**	**90/90**	**85/85**	**110/110**	**3**
A8(8)	**100/100**	**117/117**	**84/84**	**100/100**	**85/85**	**115/115**	**90/90**	**85/85**	**110/110**	**4-5**
A9(2)	**100/100**	**117/117**	**84/84**	**94/94**	**85/85**	**115/115**	**90/90**	**85/85**	**110/110**	**7**
A10(1)	**100/100**	**117/117**	**84/84**	**100/100**	**85/85**	**115/115**	**90/90**	**100/100**	**110/110**	**9**
M1(2)	**100/100**	**106/106**	**80/80**	**100/100**	**100/100**	**95/95**	**90/90**	**100/100**	**105/105**	**13-16**
M2(3)	**100/100**	**106/106**	**80/80**	**100/100**	**100/100**	**95/95**	**90/90**	**100/100**	**110/110**	**20**
M3(1)	**100/100**	**106/106**	**80/80**	**100/100**	**100/100**	**95/95**	**90/90**	**103/103**	**100/100**	**15**
M4(4)	**100/100**	**106/106**	**93/93**	**100/100**	**100/100**	**115/115**	**94/94**	**100/100**	**105/105**	**14-17-19**
M5(8)	**100/100**	**106/106**	**93/93**	**100/100**	**100/100**	**115/115**	**94/94**	**100/100**	**110/110**	**17-21-22**
M6(4)	**100/100**	**106/106**	**93/93**	**100/100**	**100/100**	**115/115**	**90/90**	**100/100**	**110/110**	**16-20**
M7(1)	**100/100**	**106/106**	**93/93**	**100/100**	**100/100**	**115/115**	**94/94**	**94/94**	**110/110**	**22**
M8(2)	**100/100**	**106/106**	**93/93**	**100/100**	**100/100**	**120/120**	**94/94**	**100/100**	**110/110**	**22**
M9(1)	**100/100**	**106/106**	**100/100**	**100/100**	**85/85**	**100/100**	**94/94**	**100/100**	**105/105**	**21**
M10(1)	**100/100**	**100/100**	**	**100/100**	**100/100**	**105/105**	**100/100**	**100/100**	**105/105**	**18**

Table 2 - Genotypic classes observed in natural populations of *Tuber aestivum* (**A**) and *T. mesentericum* (**M**); (in brackets the number of specimens); ** no enzymatic activity, presumed null allele

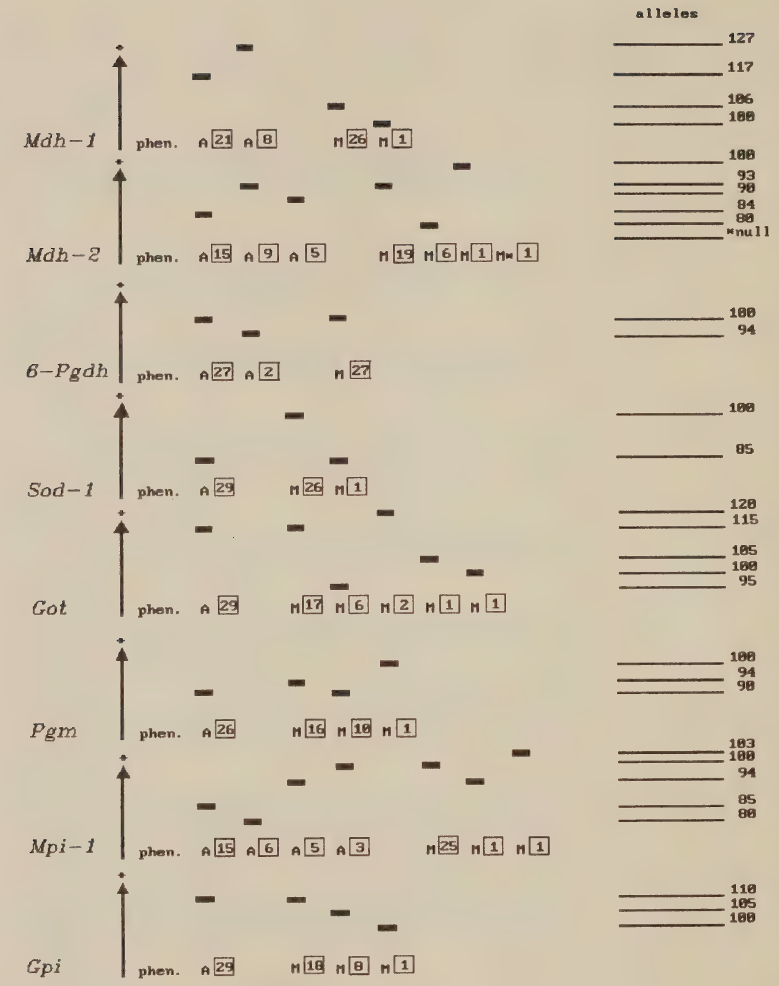

alleles
Mdh−1
phen.
A 21 A 8 M 26 M 1
127
117
106
100
Mdh−2
phen.
A 15 A 9 A 5 M 19 M 6 M 1 M* 1
100
93
90
84
80
*null
6−Pgdh
phen.
A 27 A 2 M 27
100
94
Sod−1
phen.
A 29 M 26 M 1
100
85
Got
phen.
A 29 M 17 M 6 M 2 M 1 M 1
120
115
105
100
95
Pgm
phen.
A 26 M 16 M 10 M 1
100
94
90
Mpi−1
phen.
A 15 A 6 A 5 A 3 M 25 M 1 M 1
103
100
94
85
80
Gpi
phen.
A 29 M 18 M 8 M 1
110
105
100

Fig.1 - Electrophoretic phenotypes observed for eight mark loci used to identify genotypic classes of *Tuber aestivum* (**A**) and *T. mesentericum* (**M**).
For each locus is reported the number of the observed phenotypes.

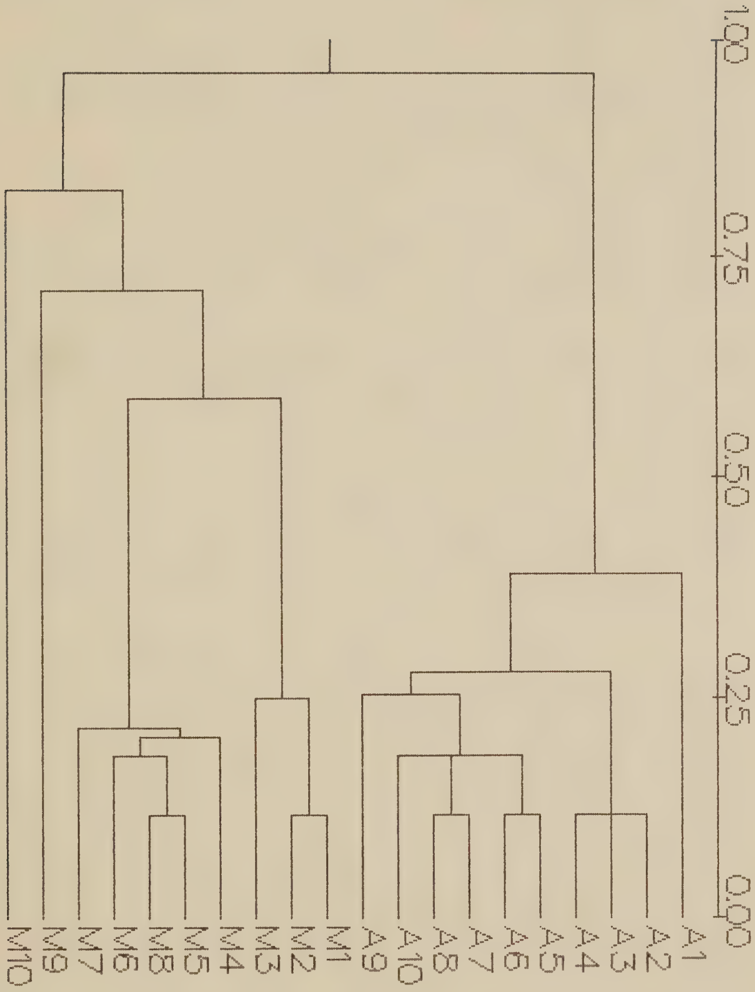


Fig.2 - Dendrogram of relative similarity for twenty genotypic classes.
A: *Tuber aestivum*; **M**: *T.mesentericum*

MYCOTAXON

Volume XLII, pp. 181-186 October-December 1991

MARASMIELLUS DUNENSIS (MARASMIACEAE, AGARICALES), A NEW SPECIES FROM THE EUROPEAN MEDITERRANEAN.

G.Robich *, G.Moreno ** & R.Pöder ***

* Via Orlanda 141 / C, 30030 Campalto (VE), Italia.
** Dpto. Biologia Vegetal (Botánica), Universidad de Alcalá de Henares, Madrid, España.
*** Institut für Mikrobiologie (N.F.), Universität Innsbruck, Technikerstraße 25, A-6020 Innsbruck, Austria.

ABSTRACT

Marasmiellus dunensis sp.nov., collected on buried parts of *Poaceae* in Mediterranean coastal dunes in Italy and Spain is described as a new species. Drawings and photographs of the most important features are given.

Marasmiellus dunensis Robich, Moreno & Pöder, *sp.nov.*

Pileo plano-convexo, interdum umbilicato, o,8-2 (2,4) cm. Cuticula carnea. Margine valde sulcato. Lamellis carneis, adnatis vel subdecurrentibus, lamellulis abundantibus, in maturitate venis ad infimum instructis. Stipite cylindrico 1,5-3,5 x 0,2-0,4 cm, centrali, concoloro, pruinoso-tomentoso, arena obtecto. Sapore odoreque fungali. Epicute filamentoso ad hyphis cylindricis, 3-10 µm diam., ramificatis, intertextis, fibulatis, brunneo-flavis instructis. Basidiis tetrasporis, 38-43x8,5-10 µm, sterigmatibus usque ad 6 µm long. Sporis ellipsoideis vel ovalis, 10-13x5-7,5 µm, hyalinis, laevis, inamyloideis, indextrinoideis, acyanophilis, 1-pluri guttulatis, candice bene evoluto. Cheilocystidiis 25-50x3-7 µm, hyalinis contortis irregularisque, saepe diverticulatis. Pleurocystidiis adsunt. Trama lamellis a mediostrato plus minusve regulari. Strato laterali parum divergentibus (bilaterali), subhimenio denso. Hyphis oleiferis dispersis. Hyphis stipite cylindricis, metachromaticis, internis latis usque ad 5-11 µm crass; externis laevis, ramificatis, fibulatis, in *caulocystidiis pleurocystidiiformis desinentibus.* ***Holotypus:*** *Italia, S. Nicolò-Lido, Venetia, cespitoso ad Poaceae in dunis littoralis, leg. L. Zambolin, 17-VI-1990, in Museo Civico di Storia Naturale Venetiae conservatus est (nº 280); Isotypus in AH.*

Cap convex to flat, sometimes umbilicate, 0,8-2(2,4)cm. Cuticle flesh coloured, resembling *Laccaria laccata*. Margin strongly furrowed, up to 0,2-0,4 cm from margin. Lamellae rather distant, L = 17-22, l = 1-3, slightly thickish, 1,5-2,5 mm broad, concolorous with the cuticle, adnate to subdecurrent by a small tooth, with abundant lamellulae, with veins at the bottom of the gills when mature. Stipe cylindric, 1,5-3,5x0,2-0,4 cm, central, concolorous with cap, pruinose-tomentose and covered by sand. Taste and odour fungal.

Epicutis filamentous, formed by cylindric, branched, interwoven, clamped, yellowish-brown hyphae, 3-10 µm diam., the pigment forming small scales which may be very thin. Basidia 4-spored, 38-43x8,5-10 µm, sterigmata up to 6 µm long. Spores ellipsoid to ovoid, 10-13x5-7,5 µm, hyaline, smooth, non amiloid, non dextrinoid, acyanophilic, whih one or more oil drops, hilum distinct. Cheilocystidia 25-50x3-7 (8) µm, hyaline, variable in shape, contorted and irregular, frequently diverticulate and septate (up to 3 septa). Pleurocystidia not observed. Gill trama with a more or less regular to subregular mediostratum. Lateral stratum very slightly diverging (bilateral). Subhymenium very dense. All structures (mediostratum, lateral stratum, subhymenium) not well differentiated; average of tramal hyphae 4-7 µm broad. Oleiferous hyphae scattered. Hyphae of stem cylindric and metachromatic (violet in cresyl blue); the internal ones up to 5-7 µm wide ; the outer ones up to 2-6 µm, smooth, branched, clamped, ending in caulocystidia similar to cheilocystidia, 20-35x2,5-5 µm.

Remarks: *Marasmiellus dunensis* is close to *M. carneopallidum* (Pouzar) Singer described by POUZAR (1966), as *Micromphale carneopallidum*, *differing by its cheilocystidia, its flesh-coloured stem in all its length and concolorous with the cap, and its habitat in coastal dunes fixed by Poaceae,* mainly *Sporobolus pungens. M. carneopallidum* lacks cheilocystidia, the stem is "coffeo-brunneo" and in the steppes of Czechoslovakia on roots of *Thymus sp.*, *Artemisia campestris* and other herbs.

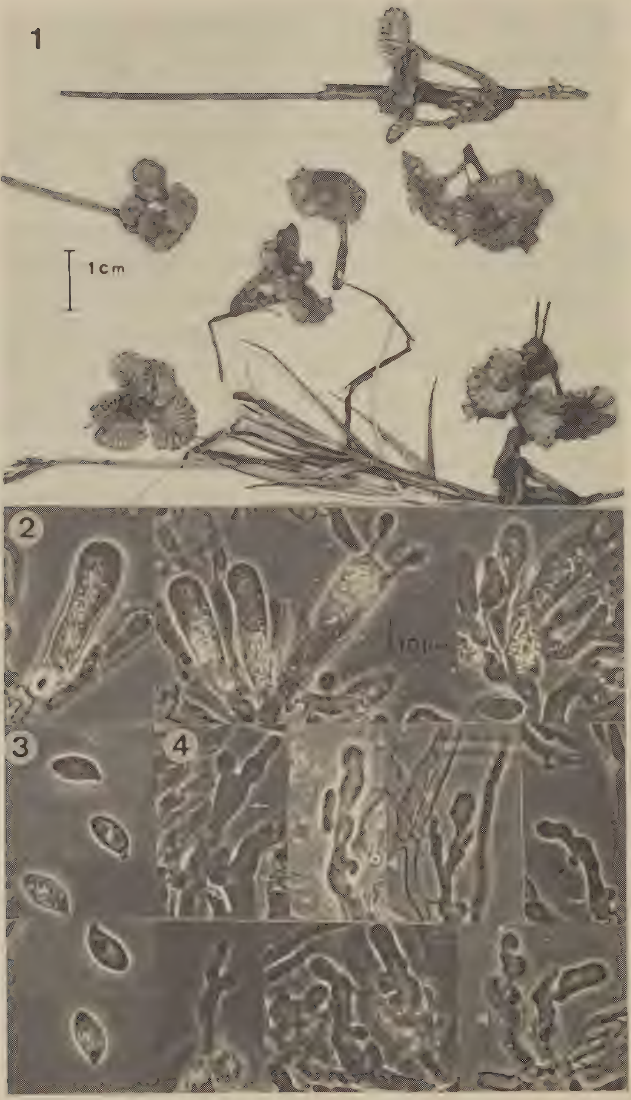
This new species has been included in *Marasmiellus* by its filamentose epicutis, formed by cylindric, branched and interwoven hyphae; it has never been observed gelatinized and for this reason it is different from typical species of *Micromphale*.

Material studied: Cespitose on *Poaceae*, with a variable number of fruit bodies (up to 38) in coastal dunes, S.Nicolò-Lido, Venezia (Italy), leg. L.Zambolin, 17-VI-1990, Herbarium Museo Civico di Storia Naturale di Venezia nº 280 *HOLOTYPUS*; *Isotypus in* AH; cespitose in coastal dunes on *Sporobolus pungens (Poaceae)*, Prat de Llobregat, Barcelona (Spain), leg. A.Mayoral, 14-X-1991, Herbarium Museo Civico di Storia Naturale di Venezia 28o A; Ibidem, leg A.Mayoral, G.Moreno & R.Pöder, 19-X-1991, IB 90/244, *Isoparatypus in AH (Herbarium* Alcalá of Henares); Very abundant on dry pasts (rhizomes and buried stems) of *Sporobolus pungens (Poaceae)*, in nitrophilous, fixed coastal dunes, Ribera of Cabanes, Castellón (Spain), leg. G.Moreno & A.Burguete, 10-XI-1990, AH 12680. *Isoparatypus* in MA Fungi, IB and Museo Civico di Storia Naturale di Venezia 280B.

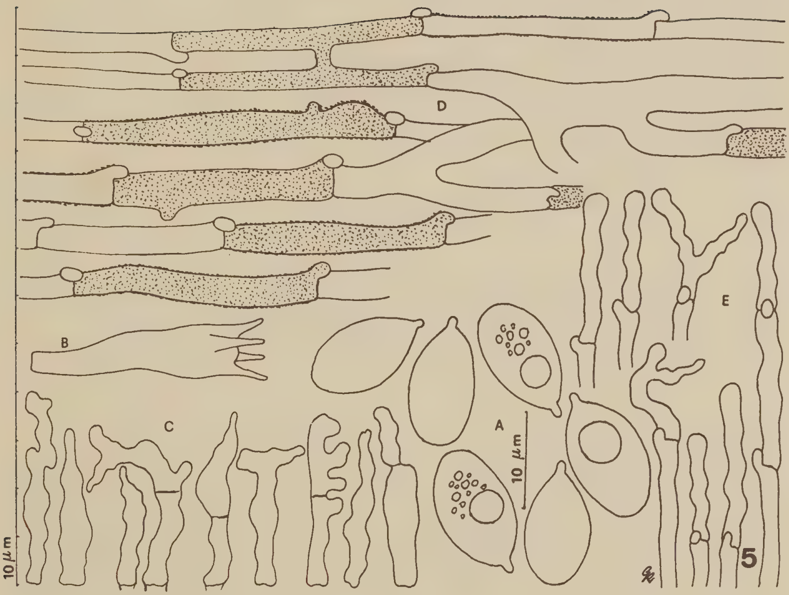
Acknowledgements: We acknowledge the" Excmo.Ayuntamiento de Esplugas de Llobregat" and the "Sociedad Micológica de Esplugas" by their invitation to attend the IV Annual Mycological Convention. We wish to thank also Messrs. J.Boada, A.Mayoral and the rest of the members of this Society for their warm reception and interest in all these studies. The authors express their gratitude to Dr.Z.Pouzar for sending us *Micromphale carneopallidum* from PRM. Thanks are due Dr.J.E.Wright for the translation into english of the text and the latin diagnosis. To Dr.F.Esteve-Raventós for his scientific revision of this work.

BIBLIOGRAPHY

POUZAR, Z. 1966.- *Micromphale carneo-pallidum* spec.nov., a new steppe fungus similar to *Marasmius oreades*. *Ceská Mykol.* 20:18-24.

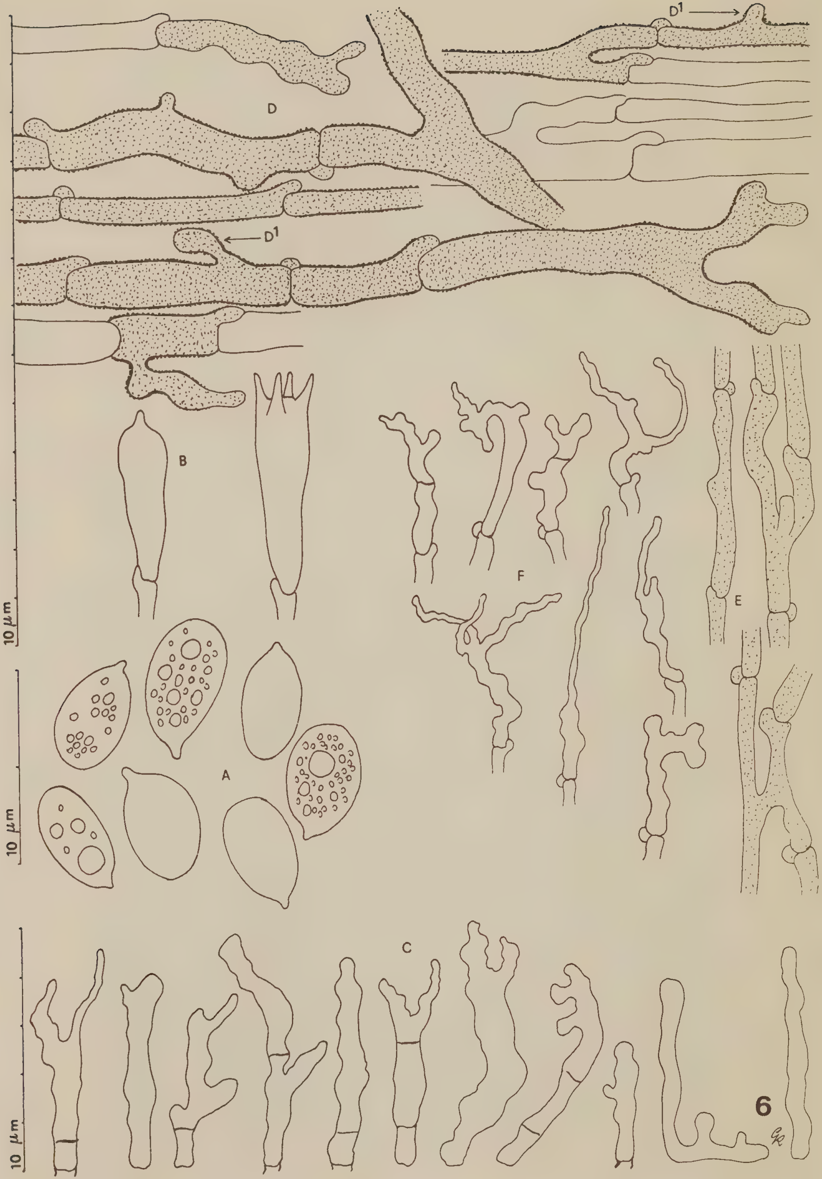

1
1cm
2
10µ
3
4

1-4.-*Marasmiellus dunensis* (AH 12680): 1. Fruit-bodies; 2. Basidia; 3. Spores; 4. Cheilocystidia.



5.-*Marasmiellus dunensis* (AH 12680): A. Spores; B. Basidia; C. Cheilocystidia; D. Epicutis; E. Caulocystidia.

6.-*Marasmiellus dunensis* (**Holotypus**): A. Spores; B. Basidia; C. Cheilocystidia; D. Epicutis; E. Hyphae of the stipe; F. Caulocystidia.


D
D1
D1
B
A
F
E
C
10 µm
10 µm
10 µm
6

MYCOTAXON

Volume XLII, pp. 187-192 October-December 1991

A NEW SPECIES OF HEMIMYCENA (AGARICALES, TRICHOLOMATACEAE) FROM ANZA BORREGO DESERT OF SOUTHERN CALIFORNIA.

DENNIS E. DESJARDIN
Department of Biology, San Francisco State University
1600 Holloway Ave., San Francisco, CA 94132

ABSTRACT

Hemimycena minutissima sp. nov. is described and illustrated from material collected in the Anza Borrego Desert of southern California, and is compared with phenetically similar taxa. The occurrence of *Hemimycena hirsuta* in the United States is substantiated for the first time.

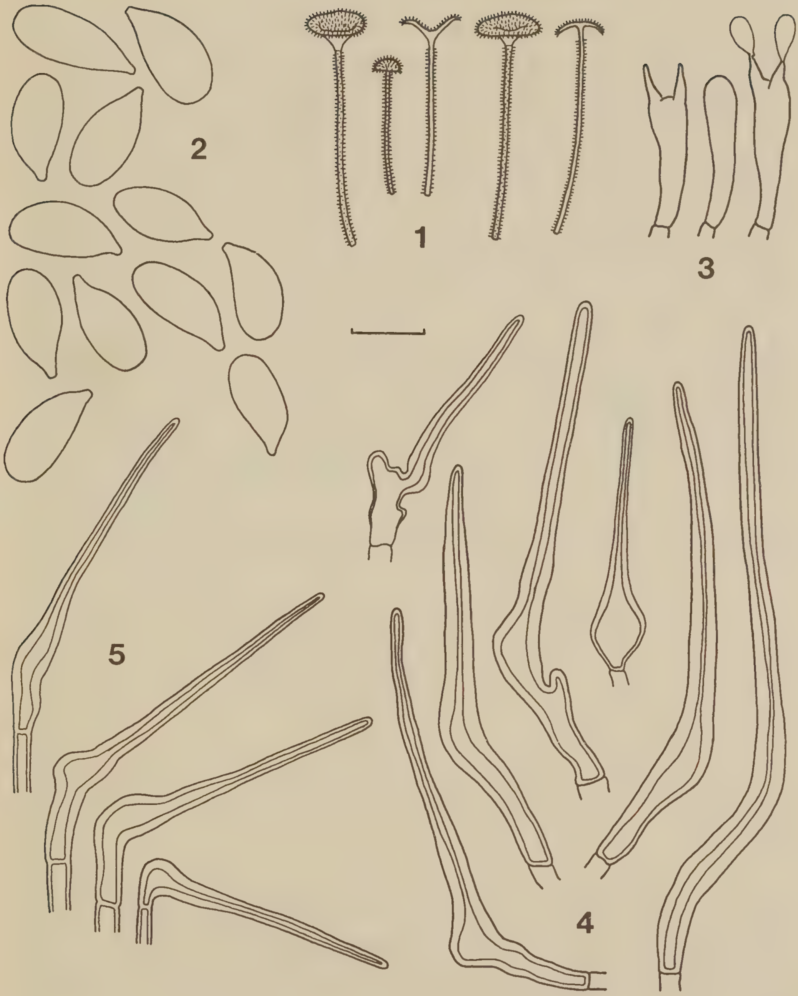
Hemimycena minutissima, a new small "reduced" agaric was collected recently on leaves of *Quercus engelmannii* Greene in the Anza Borrego Desert of southern California. Basidiomata formed on oak leaves buried approximately 10-15 cm deep in wet, homogeneous leaf litter under the canopy of a solitary oak tree adjacent to a seepage area. The basidiomata were collected soon after spring rains had soaked the litter layer. The collecting site, at an elevation of about 1100 m, represents a transition zone between chaparral and desert, dominated by *Acacia greggii* Gray, *Condaliopsis parryi* (Torr.) Suesseng., *Opuntia* spp., *Prunus fremontii* Wats., *Quercus cornelius-mulleri* Nixon & Steele, and *Rhus ovata* Wats. Habitats with low annual rainfall that are hot and dry for most of the year, such as Anza Borrego Desert, appear to be poor environments for the growth and dispersal of fleshy saprotrophic agarics, especially those with thin-walled, unpigmented basidiospores. Such basidiospores dessicate easily in arid conditions (Desjardin, unpublished data), a feature that greatly reduces basidiospore germination (Kramer & Pady, 1968) and species dispersal. Presumably, important factors influencing the survival of *H. minutissima* include the proximity of its microniche to a small seepage area, a deep leaf litter layer shaded by an extensive evergreen canopy, basidiome development soon after the onset of spring rains, and a low water requirement for the formation of exceedingly small basidiomata. Fleshy basidiomycetes capable of withstanding adverse desert conditions typically form thick-walled, darkly pigmented basidiospores. Accordingly, the more commonly encountered macrofungi in southern California deserts are gasteromycetes, secotioid coprinoid or secotioid agaricoid taxa such as *Chlamydopus meyenianus* (Klotzch) Lloyd, *Astraeus* sp., *Montagnea arenarius* (DC) Zeller, *Podaxis pistillaris* (L. ex Pers.) Fr., and *Longula texensis* (Berk. & Curt.) Zeller.

Few species of white-spored, litter-decomposing agarics referable to the genus *Hemimycena* have been reported from California. Smith (1947) reported five species which he included in *Mycena* sections *Deminutivae* A. H. Smith and *Adonideae* (Fr.) Quélet: *viz.*, *Mycena albidula* (Pk.) A. H. Smith [= *Helotium californiense* (Murr.) Redhead (1982)], *M. albissima* A. H. Smith [= *Helotium subimmaculatum* (Murr.) Redhead (1982)], *M. delectabilis* (Pk.) Sacc. [≡ *Hemimycena delectabilis* (Pk) Sing.; = *Hemimycena lactea* (Pers.: Fr.) Sing.], *M. delicatella* (Pk.) A. H. Smith [≡ *Hemimycena delicatella* (Pk.) Sing.], and *M. mcmurphyi* (Murr.) A. H. Smith. All five of these species form white basidiomata with convex or obtusely conic pilei ranging in diameter from 3-10(-20) mm, have well-developed lamellae that range from narrow to broad and subdistant to distant (6-20 per hymenophore), and form well-developed central stipes ranging in length from 10-40 mm. In addition, all five species possess clamp connections and primarily tetrasporic basidia, and all lack pilosetae (*fide* Kühner, 1938; Kühner & Valla, 1972; Smith, 1938, 1947; personal examination of specimens at SFSU). The new species described below is distinct from all other Hemimycenas because of its exceedingly small size, convex to deeply depressed and hispid pileus, reduced hymenophore lacking lamellae, numerous pilosetae, bisporic basidia, lack of clamp connections, and the unusual habitat.

Hemimycena minutissima Desjardin *sp. nov.*

Pileus 0.2-0.7 mm *diametro, primo convexus, margine involutus, postremo planus vel depressus, hispidus, albus. Lamellae nullae; hymenophorum laeve, album. Stipes* 1.0-2.0 X 0.1 mm, *centralis vel eccentricus, filiformis, hispidus, insititius, albus. Basidiosporae* 6.0-8.0 X 3.0-3.5 µm, *ellipsoideae vel sublacrimiformes, laeves, hyalinae, inamyloideae. Basidia bisporigera, efibulata. Hymenium sine cystidiis. Pileipellis ex hyphis et pilosetis numerosis composita; hyphae implexae, non diverticulatae; pilosetae* 25-90 X 4.0-11.2 µm, *lanceolatae, fusoideae vel cylindrico-acuminatae, hyalinae, inamyloideae, crassitunicatae, parte inferiore ventricosa vel irregulari. Trama ex hyphis non gelatinosis, hyalinis, inamyloideis, efibulatis, tenuitunicatis composita. Superficies stipitis caulosetis pilosetarum similibus praedita. Basidiomata solitaria vel dispersa in foliis humatis Quercus engelmannii. Holotypus:* California, San Diego Co., Anza Borrego Desert State Park, Culp Valley, 25 March 1991, Desjardin no. 5061 (SFSU); *Isotypus* (NY).

Basidiomata (Fig. 1) fragile, putrescent. **Pileus** 0.2-0.7 mm diam, at first convex or plano-convex with inrolled margin, becoming plane with decurved margin, in age centrally depressed, sometimes infundibuliform; surface hispid, dry, white overall; context thin, white. **Lamellae** absent, no radiating veins observed; hymenophore smooth, subdecurrent, white. **Stipe** 1.0-2.0 X 0.1 mm, central or eccentric, filiform, terete, equal, insititious, pruinose to hispid overall, white overall



Figures 1-5. *Hemimycena minutissima* (holotype) Fig. 1. Basidiomata, x30. Fig. 2. Basidiospores. Fig. 3. Basidia and basidioles. Fig. 4. Pilosetae. Fig. 5. Caulosetae. Standard bar = 5 µm for Fig. 2; 10 µm for Figs. 3-5.

when fresh, base remaining white or becoming pale incarnate when dried. **Odor** not distinctive. **Taste** not recorded.

Basidiospores (Fig. 2) 6.0-8.0 X 3.0-3.5 µm [$\bar{x}$ = 7.2 ± 0.5 X 3.3 ± 0.2 µm, E = 1.9-2.5, Q = 2.2 ± 0.16, n = 40], ellipsoid or sublacrymoid, inequilateral in profile, smooth, hyaline, inamyloid, thin-walled. **Basidia** (Fig. 3) 12.5-16.0 X 4.8-6.5 µm, bisporic, subclavate or clavate, sterigmata prominent, hyaline. **Basidioles** (Fig. 3) cylindric or clavate, broadly obtuse. **Hymenial cystidia** absent. **Pileipellis** a cutis of slightly interwoven or subparallel, radially arranged hyphae with numerous, erect or suberect setoid terminal cells (pilosetae); pileipellis hyphae 3.0-8.0 µm diam, cylindric or slightly inflated, non-diverticulate, non-gelatinous, hyaline, inamyloid, thin-walled; **pilosetae** (Fig. 4) 25-90+ X 4.0-11.2 µm at the broadest basal portion, 1.5-5.0 µm diam at the upper elongate portion, numerous, lanceolate, fusoid, or cylindric-acuminate, lower central or basal portion often swollen and irregular in outline, with irregularly thickened walls up to 2.0 µm thick, walls thinner towards the subacute apex and towards the base (up to 0.5 µm thick), hyaline, inamyloid. **Hypodermium** not differentiated. **Tramal hyphae** 3.0-7.0 µm diam, interwoven, cylindric or irregular in outline, non-gelatinous, hyaline, inamyloid, thin-walled. **Stipe tissue** monomitic; cortical and medullary hyphae undifferentiated, 1.2-5.0 µm diam, parallel or subparallel, cylindric, hyaline, inamyloid, thin-walled or firm-walled (<0.5 µm thick); the terminal cells of some cortical hyphae angled to perpendicular to stipe surface and differentiated as thick-walled **caulosetae** (Fig. 5) similar to the pilosetae. **Clamp connections** absent in all tissues.

Habit, habitat and distribution. Solitary or scattered (1-7 basidiomata per leaf), insititious on senescent leaves of *Quercus engelmannii*, buried in deep homogeneous leaf litter under the canopy of a solitary oak tree adjacent to a small seepage area. March. Anza Borrego Desert. Known from the type assemblage composed of 56 basidiomata.

Material Examined: **CALIFORNIA**, San Diego Co., Anza Borrego Desert State Park, Culp Valley, 25 March 1991, Desjardin no. 5061 (Holotype, SFSU; Isotype, NY).

Commentary. *Hemimycena minutissima* is characterized by formation of tiny basidiomata with convex to deeply depressed pilei less than 0.7 mm diam that are white and hispid, by a smooth hymenophore lacking lamellae, and by a small (1.0-2.0 mm long), hispid, central to eccentric stipe insititious on oak leaves. In addition, the species is distinct because of non-diverticulate pileipellis hyphae, numerous pilosetae and caulosetae, small spores, bisporic basidia and clampless hyphae.

Kühner and Valla (1972) recognized 24 taxa (as *Mycena*) currently referable to *Hemimycena*, while Redhead (1982) recognized 40 species of *Helotium* Tode (= *Hemimycena*), and Singer (1986) recognized 26 species in *Hemimycena*. Of the known worldwide species of *Hemimycena*, *H. minutissima* is directly comparable only to those species with reduced hymenophore in combination with pilosetae and bisporic basidia: *viz.*, *H. cyphelloides* (Orton) Maas Geesteranus [*nom. invalid*; see Redhead (1982: 2006)], and *H. hirsuta* (Tode) Singer [= *H. crispula* (Quél.) Sing.].

Hemimycena cyphelloides differs from *H. minutissima* in forming larger basidiomata (pileus 0.5-3.0 mm diam; stipe 2-19 mm long), diverticulate pileipellis hyphae, apically branched and thin-walled pilocystidia on the pileus margin, much larger spores (11.0-16.0 X 3.7-5.0 µm), and appears to be restricted to monocotyledonous substrata (*Carex*, *Scirpus*) (*fide* Kühner & Valla, 1972; Redhead, 1982). *Hemimycena hirsuta* differs in forming larger basidiomata (pileus 1-10 mm diam; stipe 2-17 mm long), diverticulate pileipellis hyphae, clamped basidia and hyphae, broader spores (4-5 µm diam, $\bar{w}$ = 4.6 µm), and narrower (3.2-5.0 µm diam), slightly thinner-walled pilosetae (*fide* Kühner & Valla, 1972 [as *Mycena crispula* (Quél.) Kühn.]; Malençon & Bertault, 1975 [as *Delicatula crispula* (Quél.) Kühn. & Romag.]; Redhead, 1982). *Hemimycena minutissima* differs from other known clampless and primarily bisporic taxa referable to the genus *Hemimycena* by the absence of lamellae, absence of diverticula on pileipellis hyphae, presence of pilosetae, and by its exceedingly small basidiomata [compare with *Mycena delectabilis* var. *bispora* Kühner, *M. gypsella* Kühner, *M. mauretanica* var. *apogama* Kühner, *M. pseudocrispata* Valla, *M. pseudogibba* Valla; *sensu* Kühner & Valla (1972)].

Hemimycena minutissima competes with *Marasmius perreductus* Singer (1978), *Marasmius pusillissimus* Desjardin & Petersen (1989), and *Marasmius rosulatus* Desjardin & Petersen (1989) for being the smallest agaric known.

Notes on *Hemimycena hirsuta*.

Redhead (1982) reported that *H. hirsuta* was known in North America with certainty only from specimens collected from the west coast of British Columbia, Canada (deposited at DAOM). Basidiomata of these specimens were collected on damp leaves and stems of beachgrass, a legume, a labiate, and on a cone of *Pseudotsuga menziesii* (Mirb.) Franco. According to Redhead, material collected from Oregon and determined by Smith (1947) as *Mycena crispula* (= *H. hirsuta*) represents*Hemimycena pseudocrispula* (Kühn.) Sing. While examining numerous herbarium specimens tentatively determined as *Hemimycena*, several collections of *H. hirsuta* from California were uncovered. Basidiospore size of the California specimens of *H. hirsuta* measured 8.3-11.2 X 4.2-5.5 µm [$\bar{x}$ = 9.7 ± 0.1 X 4.9 ± 0.04 µm, Q = 2.0 ± 0.01, n = 20 spores per 3 specimens (SFSU)], and was similar to that reported by Kühner and Valla (1972; as *M. crispula*; 7.5-11.0 X 4-5 µm) and Malençon and Bertault (1975; as *D. crispula;* 8.5-11.0 X 4-5 µm) for French and Moroccan material. Redhead (1982) reported basidiospore size in the British Columbian specimens of *H. hirsuta* as 7-9 X 4.5-4.8 µm. These data are very similar to those obtained from a specimen collected in Great Smoky Mountains National Park in the southern Appalachian Mountains of Tennessee, *viz.*, 6.8-9.6 X 4.0-5.0 µm. The California specimens of *H. hirsuta* were collected on wet leaves of an undetermined fern and on *Umbellularia californica* (H. &

A.) Nutt., while the Tennessee specimen was collected on wet leaves of various deciduous hardwoods.

Specimens of *H. hirsuta* Examined. CALIFORNIA. Marin Co., Audubon Canyon Ranch, 4 Oct 1981, Calhoun no. 81-2354; same location, 11 Oct 1981, Calhoun no. 81-2392; same location, 4 Nov 1982, Calhoun no. 82-3409; same location, 25 Nov 1984, Calhoun no. 84-3874. **TENNESSEE.** Blount Co., Great Smoky Mt. National Park, Parsons Branch Rd., 10 Sept 1987, Desjardin no. 4514. All SFSU.

ACKNOWLEDGMENTS

I am most grateful to Dr. Scott Redhead (DAOM) for discussions on *Hemimycena* and *Helotium*, to Dr. Robert Patterson (SFSU) for introducing me to the collecting site, to Mrs. Ellen Thiers for writing the Latin diagnosis, and to Drs. Timothy Baroni, Scott Redhead and Harry Thiers for kindly reviewing the manuscript.

LITERATURE CITED

Desjardin, D. E., and R. H. Petersen. 1989. Two new *Marasmius* species from New Zealand. *New Zealand J. Bot.* 27: 275-279.

Kramer, C. L., and S. M. Pady. 1968. Viability of airborne spores. *Mycologia* 60: 448-449.

Kühner, R. 1938. Le genre *Mycena* (Fries). *Encycl. Mycol.* 10: 1-710.

Kühner, R., and G. Valla. 1972. Contributions à la connaissance des espèces blanches à spores non amyloïdes du genre *Mycena* (Fries) S. F. Gray (Basidiomycètes, Agaricales). *Trav. Lab. La Jaysinia, Fasc.* 4: 25-71.

Malençon, G., and R. Bertault. 1975. Flore champignons supérieurs du Maroc. II. *Trav. Inst. Sci. Chérifien Sér. Bot. Biol. Vég.* 33: 1-539.

Redhead, S. A. 1982. The application of *Helotium* to agarics. Part. I. Nomenclature. Part II. Notes on selected species from Canada. *Can. J. Bot.* 60: 1998-2013.

Singer, R. 1978. Interesting and new species of Basidiomycetes from Ecuador. II. *Nova Hedwigia* 29: 1-98.

________. 1986. The Agaricales in modern taxonomy. 4th Ed. Koeltz Scientific Books, Federal Republic of Germany. 981 p.

Smith, A. H. 1938. New and unusual agarics from North America - I. *Mycologia* 30: 20-41.

________. 1947. North American species of *Mycena*. Univ. of Michigan Press, Ann Arbor, MI. 521 p.

MYCOTAXON

Volume XLII, pp. 193-200 October-December 1991

NANNIZZIOPSIS (ASCOMYCOTINA) AND RELATED GENERA

J. Guarro[1], J. Cano[1] & Ch. de Vroey[2]

[1]Unitat de Microbiologia, Facultat de Medicina, Universitat de Barcelona, 43201-Reus, Tarragona, Spain.

[2]Laboratory for Mycology, Institute of Tropical Medicine, Nationalestraat 155, B-2000 Antwerpen 1, Belgium

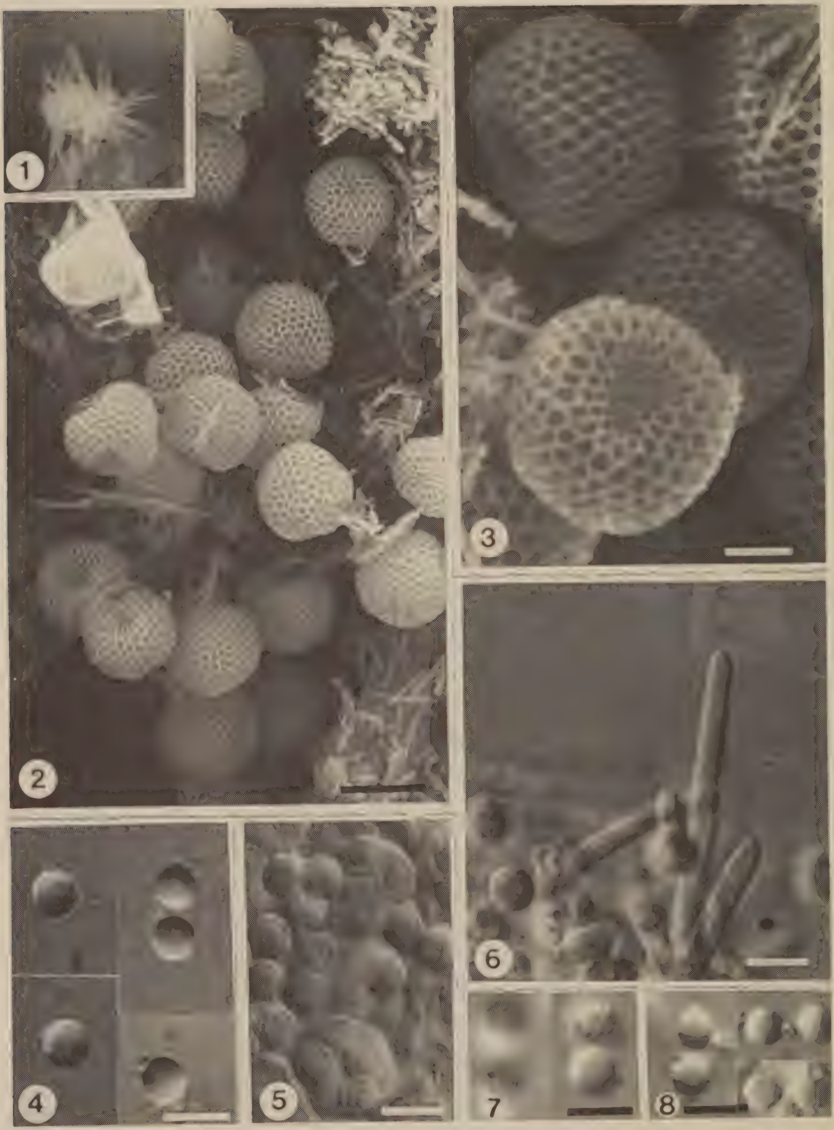
SUMMARY

The genus *Nannizziopsis* Currah has been re-evaluated and three species have been accepted; relationships with similar genera are discussed. This genus is characterized by globose to ovate, single or clustered, white ascomata; peridium is formed by a network of loosely interwoven, hyaline, smooth or asperulate hyphae, septate, occasionally constricted at septa; asci globose to subglobose, hyaline, thin walled, 8-spored; ascospores globose to subglobose, hyaline, occasionally pigmented in mass, thick-walled, punctate-reticulate (occasionally smooth under light microscopy).

A key to accepted species is given in addition to a key to the genera of Eurotiales with globose ascospores. Photomicrographs of *Nannizziopsis* and related species are provided. The following new species and new combinations are proposed: ***Nannizziopsis hispanica*** Cano et Guarro **sp. nov.**, ***Nannizziopsis albicans*** (Apinis) Guarro, Cano et De Vroey **comb. nov.**, ***Apinisia racovitzae*** (Lagarde) Guarro, Cano et De Vroey **comb. nov.**

INTRODUCTION

V. Arx (1971) established the genus ***Arachnotheca*** for gymnoascaceous fungi with light ascomata with a peridium composed of hyaline anastomosing hyphal cells, hyaline and small ascospores with a thick wall surrounded by an irregularly furrowed sheath and cylindrical and hyaline arthroconidia separated by adjacent septa (fission). The type species was ***Arachnotheca glomerata*** (Müller & Pacha-Aue) v. Arx which was before included in ***Arachniotus*** Schroeter. Two later species were added to this genus, ***Arachnotheca albicans*** (Apinis) v. Arx (v. Arx, 1974) and ***Arachnotheca vriesii*** (Apinis) Samson apud v. Arx (v. Arx, 1981). However the features of these two species do not fit the original description of the genus because their ascospores do not have the typical surrounding sheath and the anamorphs are ***Chrysosporium***. We have examined the types and representative strains of these species and observed in ***A. glomerata*** (CBS 348.71, UAMH 3801) (Fig. 2.4) the typical sheath which is broad and complete in the young ascospores; becoming irregularly furrowed when they mature and nearly lacking in old ascospores in which we can only see a distinct reticular wall; the mature ascospores show a slighty yellowish to brown pigmentation. These characteristics are not present in the other two species. In consequence we think that ***Arachnotheca*** should be restricted to the type species, ***A. glomerata***, although probably some species of ***Amauroascus*** Schroeter should be included (Cano & Guarro, 1989). The other two species fit well in ***Nannizziopsis*** Currah. This genus was erected by Currah (1985) based on the species ***Rollandina vriesii*** Apinis, the present is a monotypic genus characterized by white ascomata, and asperulate peridial hyphae constricted at septa, hyaline and globose ascospores, and with a


1
2
3
4
5
6
7
8

Chrysosporium anamorph. In the revision of Eurotiales, v. Arx (1987) did not accept this genus and considered it a synonym of ***Arachnotheca***. After examining the type species of both genera we believe that there are enough features for differentiating them. In our opinion ***Nannizziopsis*** includes both species mentioned above and a third one which is described in this paper.

Nannizziopsis Currah, Mycotaxon 24: 160 (1985)

Ascomata globose to ovate, single or in clusters, white, peridium formed by a network of loosely interwoven hyaline hyphae, smooth or asperulate, septate, occasionally constricted at septa. Asci globose to subglobose, hyaline, thin walled, 8-spored. Ascospores globose to subglobose, hyaline, occasionally pigmented in mass, thick-walled, spiny to punctate-reticulate (occasionally smooth under light microscopy).

Anamorphs: ***Chrysosporium*** spp.

Type species: ***N. vriesii*** (Apinis) Currah.

Habitat: Soil.

KEY TO THE SPECIES OF *NANNIZZIOPSIS*

1a	Small ascospores (2-3 µm); peridial hyphae verrucose and constricted at the septa...	***N. vriesii***
1b	Ascospores bigger (3-5 µm); peridial hyphae without such characters.	2
2a	Ascospores smooth under light microscopy; anamorph lacking; not growing in culture; peridial hyphae with short and straight appendages blunt ; growing directly in soil, apparently not keratinophilic.................	***N. hispanica***
2b	Ascospores reticulate under light microscopy; ***Chrysosporium*** anamorph; peridial hyphae undifferentiated without appendages; growing in culture; keratinophilic..	***N. albicans***

Nannizziopsis albicans (Apinis) Guarro, Cano & De Vroey **comb. nov.**
≡***Arachniotus albicans*** Apinis, Mycol. Pap. **96**:45 (1964)
≡***Amauroascus albicans*** (Apinis) v. Arx, Persoonia **6**:376 (1971)
≡***Arachnotheca albicans*** (Apinis) v. Arx, The genera of fungi sporulating in pure culture. 2nd Ed. J. Cramer, Vaduz. p 98 (1974).

V. Arx (1977) considers ***Kuehniella racovitzae*** Orr as identical to ***Arachnotheca albicans*** . Benny & Kimbrough (1980) follow the criteria of v. Arx. However, according to Currah (1985), the ascospores of both species show enough differences to justify placement in different taxa. For this author the latter species belongs to ***Amauroascus***. Later v. Arx (1987) mantained his earlier criteria. We have

---

Fig. 1.-***Nannizziopsis hispanica.*** (IMI 341680) 1, Ascoma. 2,3 Ascospores (bar= 3µm and bar= 1µm). 4, Ascospores (bar= 5µm). 5, Asci (bar= 5µm). 6, Peridial hyphae (bar= 5µm).
Arachniotus albicans. (UAMH 3102) 7, Ascospores (bar= 5µm).
Nannizziopsis vriesii. (IMI 149994) 8, Ascospores (bar= 5µm).

examined the types of the mentioned species and agree with Currah concerning the differences between them. Furthermore ***K. racovitzae*** shows helical peridial appendages. We thus accept two different taxa but consider that it is better to transfer ***Arachnotheca albicans*** to ***Nannizziopsis*** and ***Kuehniella racovitzae*** to ***Apinisia*** La Touche.

In an earlier paper (Cano et al., 1987), we described the strain FMR 2026 and considered it as belonging to ***Arachnotheca albicans*** but, because of the presence of ascospores with a sheath and helical appendages, we now consider it a typical strain of ***Kuehniella racovitzae***. The ornamentation of this species could lead us to confusion if we observe the ascospores in different degrees of maturation, because when they are young they show an irregular epispore that is gradually transformed in to a well-defined reticule, distinctly observed only on mature ascospores. (Figs. 1.7, 2.1).

Material examined: UAMH 3102 (strain ex type of ***Arachnotheca albicans***); IMI 100875; UAMH 3765; UAMH 3800; RV 20192 from Orr as ***Amauroascus candidus***; RV 24813 from soil of Kuriange, Burundi, June 1968.

Nannizziopsis vriesii (Apinis) Currah, Mycotaxon **24**: 164 (1985)
≡***Rollandina vriesii*** Apinis, Trans. Br. mycol. Soc. **55**: 501 (1970)
≡***Arachnotheca vriesii*** (Apinis) Samson apud. v. Arx, The genera of fungi sporulating in pure culture. 3rd Ed., J. Cramer, Vaduz, p. 130 (1981).

This species has been well described and illustrated by Apinis (1970) and Currah (1985). A second strain, from soil of California (RV 24806) has ascospores with little differences in their ornamentation pattern. The ascospores of this strain are spiny when they are under SEM (Fig. 2.2) while the holotype shows, under light microscopy, a more reticulated pattern, unfortunately we could not observe it under SEM because cultures from CBS only develop the anamorph. We tentatively retain the strain RV 24806 in this species because the rest of features are very close.

The strain ex type was isolated from the skin and lungs of a lizard, and a second strain from soil of California. (Figs. 1.8, 2.2, 2.3).

Material examined: IMI 149994 (=UAMH 3598); CBS 407.71; RV 24806.

Nannizziopsis hispanica Cano et Guarro sp. nov.

Ascomata alba, globosa, solitaria vel aggregata, 0.6 - 1 mm diam. Hyphae peridii hyalinae, anastomosantes et ramosae, septatae, laeves, rectae 2 - 2.5 µm diam. Asci subglobosi vel ovati, hyalini, octospori, evanescenti, 7.5 - 8 x 6.7 - 7.5 µm. Ascosporae globosae, hyalinae, crassitunicata, tunica crassa et reticulata, 3.5 - 4 µm diam.

Holotypus: IMI 341680, isolatus ex solo, apud Carrascoy in Murcia Hispania, III-1988 (ex Faculty of Medicine of Reus FMR 2287).

Ascomata solitary, growing directly on soil, more or less spherical, white, 0.6 - 1 mm in diameter; peridial hyphae hyaline, 2 - 2.5 µm broad, loosely interwoven, anastomosed and branched, septate, smooth-walled, straight with appendage-like ends, straight. Asci subglobose to ovate, 8-spored, hyaline, 7.5 - 8 x 6.7 - 7.5 µm, evanescent. Ascospores globose, hyaline, white in mass, smooth under the light microscope, finely reticulate under SEM, 3.5 - 4 µm. Anamorph unknown. (Figs. 1.1 - 1.6).

Material examined: IMI 341680 (FMR 2287), forest soil, Sierra de Carrascoy, Murcia, Spain, March 1988; FMR 2288, forest soil, Sierra de Carrascoy, Murcia, Spain, March 1988; FMR 2706, forest soil, Jimena de la Frontera, Cádiz, Spain, August 1985; FMR 2707, arable soil, Alcora, Castellón, Spain, December 1987.

This species differs from *N. vriesii* , by its larger ascospores (2 - 3 µm diam in the latter) and by its reticulate wall under the light microscope. The ascospores of ***N. hispanica*** show small reticulations only visible under SEM. The peridial hyphae of ***N. vriesii*** are asperulate, those of ***N. hispanica*** are smooth. ***N. albicans*** ascospores are of similar size to those of ***N. hispanica***, but show a very patent reticulation visible under the light microscope.

GENERA OF EUROTIALES WITH SPHERICAL ASCOSPORES

1a Ascospores hyaline.. 2
1b Ascospores pigmented.. 7

2a Coiled appendages on the peridium present.................................. 3
2b Coiled appendages on the peridium absent................................... 5

3a Ascomata dark; peridium membranous
(Cleistoperidium, Currah, 1985)............................... ***Pleuroascus***
3b Ascomata pale; peridium formed by a network of more or less differentiated
hyphal elements.. 4

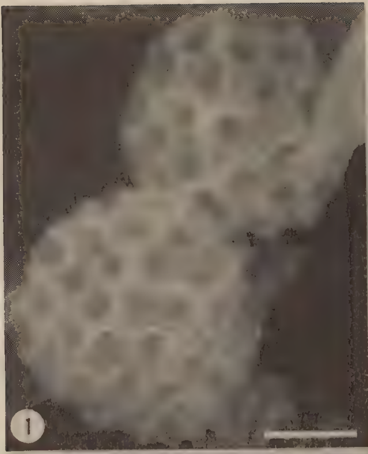
4a Parasitic on man; ascospores less than 2 µm diam without a sheath;
Histoplasma or ***Zymonema*** anamorphs.................. ***Ajellomyces***
4b Saprophytic; ascospores bigger and surrounded by an irregularly
furrowed sheath; ***Chrysosporium*** anamorph......................***Apinisia***

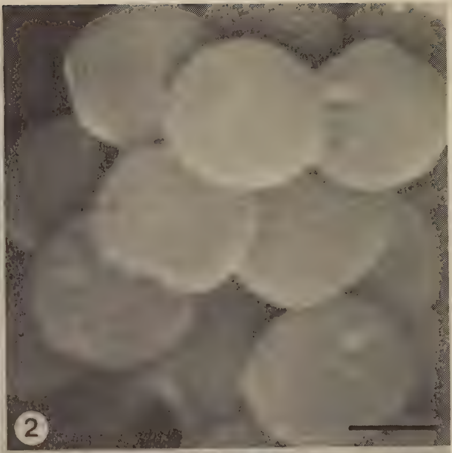
5a Ascomata dark.. ***Xylogone***
5b Ascomata white...6

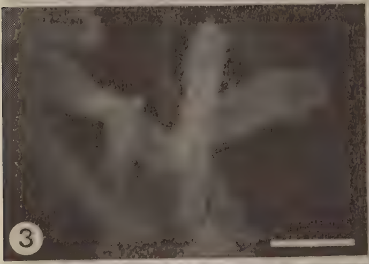
6a Ascospores slightly pigmented at maturity and surrounded by a sheath
when young; anamorph with arthroconidia separated
by two adjacent septa with disjuntives....................... ***Arachnotheca***
6b Ascospores hyaline; anamorph ***Chrysosporium***
or unknown... ***Nannizziopsis***

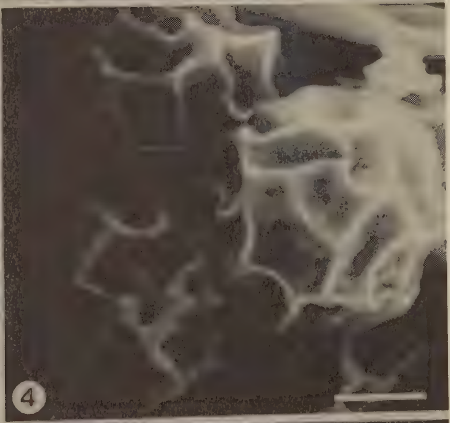
7a Peridial hyphae differentiated from vegetative hyphae and forming
a distinct reticulum .... ***Auxarthron***
7b Peridial hyphae undifferentiated from vegetative hyphae.... ***Amauroascus***

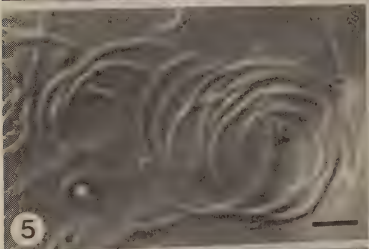
The genus ***Apinisia*** (***A. graminicola***: type species), was proposed by La Touche (1968) and characterized by white ascomata with hyaline, dense, coiled hyphae emerging from the peridial hyphae. The ascospores are hyaline, yellow in mass, with a narrow and reticulately furrowed sheath. The anamorph is a ***Chrysosporium***. A second species, ***A. queenslandica*** described later by Apinis & Rees (1976) does not fit the original description and we believe with Currah (1985) that it should be transferred to an other genus, probably ***Amauroascus*** .

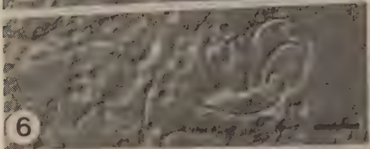

1


2


3


4

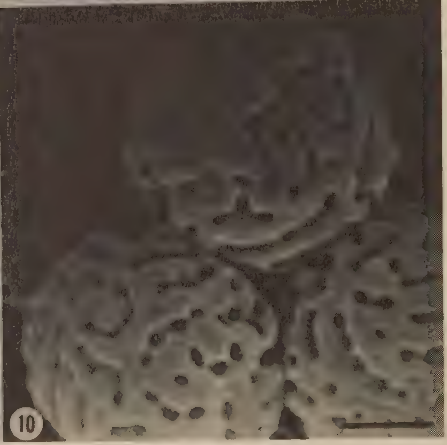

5


6

7

8

9


10

Comparing the characters of ***A. graminicola*** (IMI 126422, figs. 2.5, 2.9) with those of ***K. racovitzae*** (UAMH 3767,FMR 2026) both share general features and there is not enough reason for separing them in two different genera. According to this we propose the following new combination:

Apinisia racovitzae (Lagarde) Guarro, Cano et De Vroey **comb. nov.**
≡***Myxotrichum racovitzae*** Lagarde, Arch. Zool. Exper. Gener. **53**: 280 (1913).
≡***Gymnoascus racovitzae*** (Lagarde) Lagarde, Arch. Zool. Exper. Gener. **53**: 281 (1913).
≡***Kuehniella racovitzae*** (Lagarde) Orr, Mycotaxon (1976).

Apinisia is closely related to ***Ajellomyces*** and their only differences are in the anamorphs, which are ***Chrysosporium*** in ***Apinisia*** and ***Zymonema*** and ***Histoplasma*** in ***Ajellomyces***. In the future, if new species of such genera are found and studied in depth it will be justified to synonymize the above genera. (Figs. 2.6, 2.8, 2.10).

ACKNOWLEDGEMENTS

This work was supported by grant n° PB86-0319 from DGICYT. We wish thank to Center of Electron Microscopy of the University of Barcelona for the use of their equipment and to the Curators of UAMH and IMI for providing strains.

REFERENCES

1. Apinis, A. E. (1970): Concerning ***Rollandina***. Trans. Br. mycol. Soc. **55**: 499-502.

2. Apinis, A. E. & Rees R.G. (1976): An undescribed keratinophilic fungus from southern Qeensland. Trans. Br. mycol. Soc. **67**: 522-523.

3. Arx , J.A. von (1971): On ***Arachniotus*** and related genera of the Gymnoascaceae. Persoonia **6**: 371-380.

Fig. 2.-***Nannizziopsis albicans*** (RV 20192) 1, Ascospores (bar = 1μm).
Nannizziopsis vriessi (RV 24806) 2, Ascospores (bar = 1μm) 3, Peridial hphae.(bar = 5μm).
Arachnotheca glomerata (UAMH 3801) 4, Ascospores (bar = 1μm).7, Ascospores (bar = 5μm).
Apinisia graminicola (IMI 126422) 5, Coiled appendages (bar = 10μm).9, Ascospores (bar = 5μm).
Apinisia racovitzae (UAMH 3767) 6, Coiled appendages (bar = 10μm). 8, Ascospores. (bar = 5μm), 10, Ascospores (bar = 1μm).

4. Arx, J.A. von (1974): The genera of fungi sporulating in pure culture. Ed. J. Cramer. 2nd ed.

5. Arx, J.A. von (1977): Notes on Gymnoascaceae. Persoonia **9**: 393-400.

6. Arx, J.A. von (1981): The genera of fungi sporulating in pure culture. Ed. J. Cramer. 3rd ed.

7. Arx, J.A. von (1987): A re-evaluation of the Eurotiales. Persoonia **13**: 273-300.

8. Benny, G. L. & Kimbrough, J.W. (1980): A synopsis of the orders and families of Plectomycetes with keys to genera. Mycotaxon **12**: 1-91.

9. Cano, J. & Guarro, J. (1989): Two new keratinophilic Ascomycetes from Spain.Studies in Mycology. **31**: 61-67

10. Cano, J., Guarro, J & Figueras, M.J. (1987): Some keratinophilic fungi from Spain. Mycopathologia **100**: 163-167.

11. Currah, R.S. (1985): Taxonomy of the Onygenales: Arthrodermaceae, Gymnoascaceae, Myxotrichaceae and Onygenaceae. Mycotaxon **24**: 1-216.

12. La Touche, C.J. (1968). ***Apinisia graminicola*** gen. et sp. nov. Trans. Br. mycol. Soc. **51**: 283-285.

MYCOTAXON

Volume XLII, pp. 201-238 October-December 1991

HYPOGEOUS FUNGI FROM PENINSULAR SPAIN. II[1]

by G. MORENO*, R. GALAN* & A. MONTECCHI**

* Department of Plant Biology (Botany), University of
Alcalá de Henares (Madrid) Spain.

** Via Carducci, 20-Scandiano (RE). Italy.

ABSTRACT- Twenty-four taxa mostly from SW Spain were studied, belonging to *Ascomycotina* and *Basidiomycotina*. Among them *Elaphomyces anthracinus* Vitt., *Hymenogaster cerebellum* Cavara, *Hysterangium stoloniferum* var. *rubescens* (Quélet) Zeller & Dodge, *Octavianina asterosperma* (Vitt.) Kuntze, *Tuber asa* Tul. & C. Tul., *T. nitidum* Vitt. and *T. panniferum* Tul. & C. Tul. are new records for Spain. The definitive presence of *Hymenogaster citrinum* Vitt. in Spain is confirmed, and the distribution of other taxa is broadened. *Martellia mediterranea* Moreno, Galán & Montecchi and *Elaphomyces trappei* Galán & Moreno are proposed as new species. Taxonomic, ecological and chorological observations, as well as an exhaustive iconographic study are furnished.

INTRODUCTION

Proceeding with the same line of research which we began on occasion of the 2nd. Joint-Meeting of Mycology (Barcelona, 1984) whose results have been published (MORENO & al., 1986), this paper deals with a group of *Ascomycotina* and *Basidiomycotina* whose ecological and phenological peculiarities, together with their taxonomic difficulties, are poorly known in Spain.

Most of the material studied on this occasion is from Extremadura, particularly the Monfragüe Natural Park (Cáceres), and the region of Priego (Córdoba), sent to us by Mr. Javier Gómez, an enthusiastic collector of these fungi. A less important lot is from such distant localities as Madrid, Catalonia or Galicia.

MATERIALS AND METHODS

---

1. Paper presented in two parts at the IV Joint Meeting of Mycology, Oct. 3-5, 1988 at La Manga del Mar Menor (Murcia) and the V Joint Meeting of Mycology, Oct. 1-3, 1990, Barcelona.

Photomicrographs have been made with a Nikon "Optiphot" research microscope with automatic photographic equipment, phase contrast and interdifferential Nomarski contrast. SEM photomicrographs were made with either an ISI or Zeiss instrument.

The collections are deposited with the herbarium of the Department of Plant Biology (Botany), University of Alcalá de Henares, and duplicates in the herbarium of A. Montecchi, MA-Fungi (Real Jardín Botánico, Madrid) and in the herbarium of Proffesor James M. Trappe (Oregon State University).

COLLECTIONS STUDIED

ASCOMYCOTINA

Balsamia vulgaris Vitt.

Under *Cistus albidus* L., Priego de Córdoba (Córdoba), J. Gómez (without data), GM-RG 11892.

Remarks.-

Only one hardly mature ascocarp was found, ca. 35 mm diam., more or less irregular, externally dark reddish and provided with small, dense compressed warts; internally it exhibits a white to pale yellowish "gleba" organized into multiple irregular chambers. Microscopically, the asci are club-shaped to ellipsoid, distinctly pedicellate (Figs. 1-2); the ascospores are hyaline, smooth, cylindric, 19-26 x 9-12 µm (Figs. 3-5).

According to HAWKER (1954) the European species of *Balsamia* can be distinguished microscopycally by the shape of asci and ascospores.

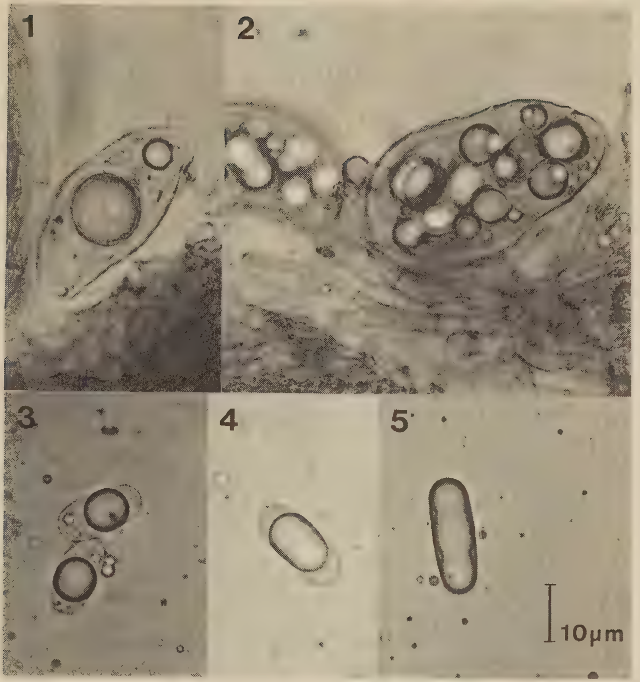
The first and only record of *B. vulgaris* from Spain was made by CALONGE & al. (1985b) in the province of Barcelona. Very recently, CABALLERO-MORENO (1990) recorded *B. fragiformis* from La Rioja, but we lack data leading to this identification.

Choiromyces magnusii (Matt.) Paoletti in Sacc.

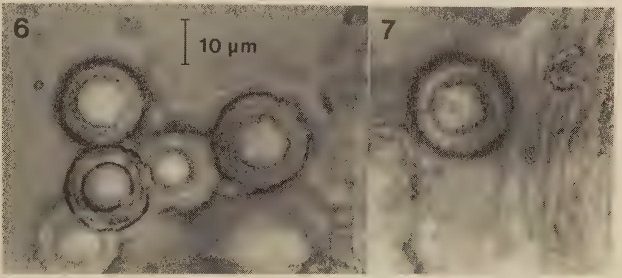
≡ *Terfezia magnusii* Matt., Mem. Acc. Sc. Torino, 2:38, 390, t. 1, f. 8-9, t. 2, f. 2 (1887)

= *Choiromyces gangliformis* Vitt., Mon. Tub.: 51, t. 2, f. 2 (1831).

Among *Cistus ladanifer* L., in acid soil, Herreruela, Sierra de San Pedro (Cáceres), J. Espárrago (1.V.1988), GM-RG 11052; Ibidem (20 & 21.IV.1989), GM-RG 11893 &



Figs. 1–5. ***Balsamia vulgaris*****,** GM-RG 11892: Figs. 1,2. Inmature asci; Figs. 3-5. Ascospores.



Figs. 6–7. ***Choiromyces magnusii*****,** GM-RG 11052: Ascospores.

11895; Azuaga (Badajoz), J.R. García (21.IV.1989), GM-RG 11896; Lobón (Badajoz), J. Espárrago (8.V.1989), GM-RG 11894 & 11912.

Remarks.-

This species, as we have been able to verify, is known popularly as "criadilla jarera" to differentiate it from the "criadilla de tierra" (*Terfezia* spp.) both of gastronomic interest in Extremadura. In Spain it was only known from this region (CALONGE & al., 1985a; GIL & DIE, 1989). Its natural distribution is circum-mediterranean, having been found also in Portugal, Italy, France (CERUTI, 1960), Morocco and Hungary (CALONGE & al., op. cit.)

Our material coincides with the description given by CALONGE & al. (op. cit.) with the exception of the nonamyloid asci; it is worth mentioning in the latter paper the excellent photograph illustrating the characteristic spore ornamentation under SEM, shown under the Light Microscope in figs. 6-7.

Elaphomyces anthracinus Vitt., Monographia Tuberacearum: 66, pl. 3, fig. 8 (1831).

Under *Quercus ilex* subsp. *ballota* (= *Q. rotundifolia*), Priego de Córdoba (Córdoba), J. Gómez (19.IV.1989), GM-RG 11897 (dupl. in Herb. J. M. Trappe).

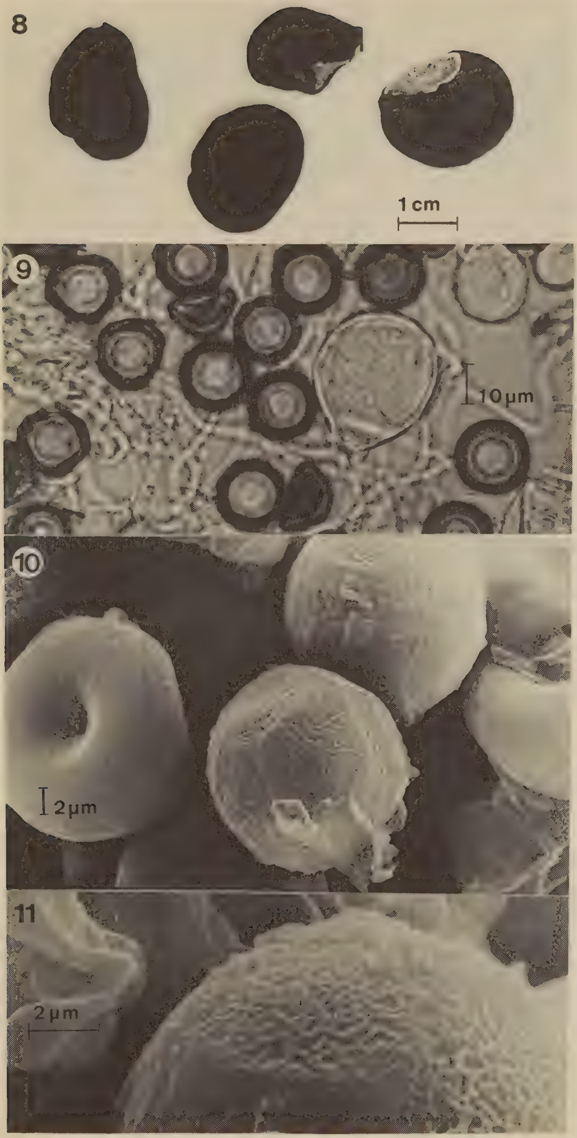
Description.-

Ascocarps more or less globose, with deep depressions, 20-25 mm diam. Peridium coriaceous, not deformed, thick (ca 1 mm) externally subsmooth, dark greyish brown (almost black) with both purplish and greyish hues (Fig. 8). Gleba unilocular, filled with the mass of spores previously shed, cottony, cinereous. Asci globose or pyriform, evanescent, 30-40 µm Ascospores globose, greyish-yellowish, ornamented with numerous shallow alveoli, 13-18 µm diam., dispersed in a trama of narrow, hyaline, straight or sligtly tortuous hyphae (Figs. 9-11).

Remarks.-

The identification of the material does not offer any difficulty since the macroscopic aspect of the fruit body (Fig. 8) inmediately recalls the traditional carbon balls used by railways long ago, hence the opportune specific epithet ("*antracinus*" = coal) given by Vittadini.

According to Proff. J. M. Trappe (pers. comm.), who confirmed our original identification, "the spores are


8
1 cm
9
10 µm
10
2 µm
11
2 µm

Figs. 8–11. *Elaphomyces anthracinus*, GM-RG 11897: Fig. 8. Sporocarps; Fig. 9. Ascus and ascospores; Figs. 10-11. Electron photomicrograph of the ascospores.

somewhat small for the species, but then it is a young specimen; otherwise, all characters fit well."

Thus, the almost black subsmooth, petreous peridium, together with the small ascospores allows an early diagnosis of the species, that was described and illustrated by TULASNE & TULASNE (1851), HAWKER (1954) and CERUTI (1960), among others.

Only two species belonging to *Elaphomyces* Nees:Fr.have been previously recorded from Spain, namely *E. granulatus* Fr. (CALONGE & al., 1977) and *E. persoonii* Vitt. (CODINA & FONT-QUER, 1930); *E. anthracinus* Vitt. is the third addition to its flora.

Elaphomyces trappei Galán & Moreno *sp. nov.* (Figs. 12-17).

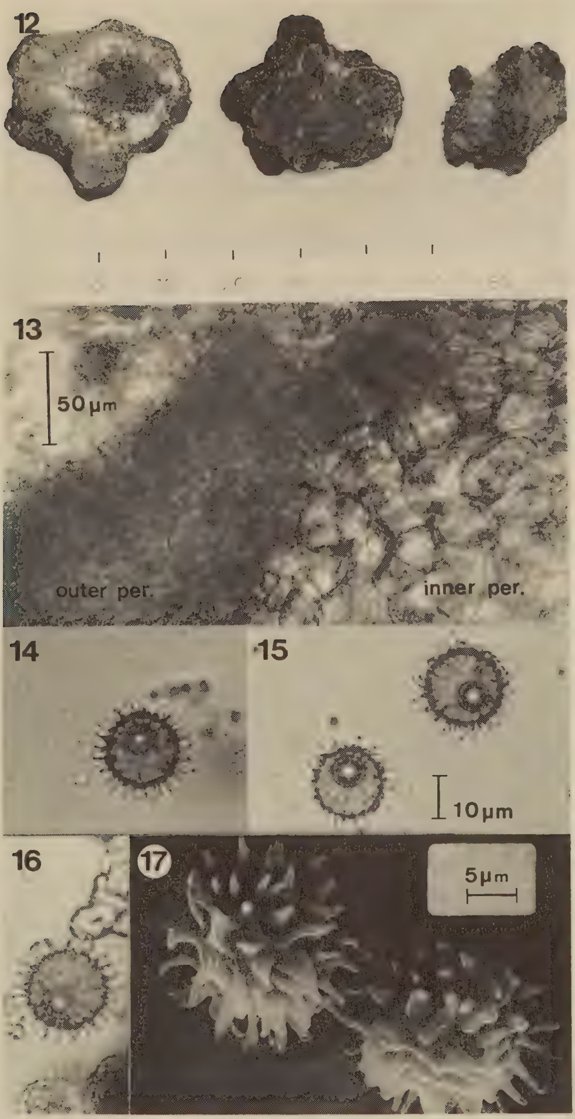
Ascocarpo gibboso, fusco, subpubescens, ca. 2.5 cm diam. Gleba unilocularis, compacta, homogenea, pulveracea, fusco-olivacea. Peridio circa 1 mm crasso, extra strato termi hyphis parallelis intermixtis instructo interdum procurrentibus in pilis brevis; intra peridio cellulis globosis, crassetunicatis, fulvis instructo. Ascis globosis in juventute, fatiscentibus in aetate, 6-8 sporis. Ascosporis globosis, ochraceis, 15.5-18.5 µm diam. (sine ornamentatione), spinosis, spinis conicis, sejunctis, subinde uncinatis, 3-5 µm alt.

Holotypus Badajoz, Lobón, leg. J. Espárrago 8.V.1989 in solo schistaceo sub Cistus ladanifer L. ad Choiromyces magnusii (Matt.) Paoletti intermixto, in Herb. GM-RG 11898 conservatus est; Isotypus in Herb. J. M. Trappe.

Ascocarps gibbous, externally fuscous, subpubescent, ca. 2.5 cm diam. Gleba unilocular, compact, homogeneous, powdery, fusco-olivaceous (Fig. 12).

Peridium ca. 1 mm thick, externally formed by a thin layer of interwoven hyphae arranged parallel to the surface and, sometimes, projecting as "hairs"; inwardly the peridium proper is formed by thick walled, yellowish globose cells, whose colour and caliber diminish towards the gleba (Fig. 13). Asci when immature globose, disintegrating at maturity, stages at which compact groups of 6-8 ascospores dispersed in a trama of thin, yellowish, very intrincate hyphae (x2-3 µm) are commonly observed. Ascospores globose, ochraceous, 15.5-18.5 µm diam. (ornamentation excluded), provided with long, isolated more or less conical spines with occasional uncinate tips, reaching 3-5 µm high (Figs. 14-17).

In slate soils, under *Cistus ladanifer* L. and living in the environs of *Choiromyces magnusii* (Matt.) Paoletti; Lobón (Badajoz), J. Espárrago (8.V.1989), GM-RG 11898 Holotypus (Isotypus in Herb J. M. Trappe).


12
13
50 µm
outer per.
inner per.
14
15
10 µm
16
17
5 µm

Figs. 12–17. ***Elaphomyces trappei*** Galán & Moreno, ***holotypus***: Fig. 12. Sporocarps; Fig. 13. Cross-section of the peridium; Figs. 14-17. Ascospores.

Remarks.-

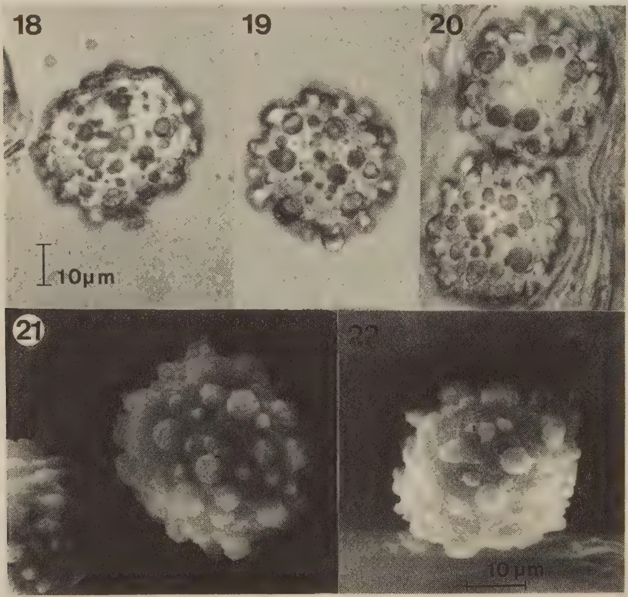
In Prof. Trappe's own words (pers. comm.): "This species is clearly undescribed; the tall ornamentation of generally unconnected spines on relative small, light-colored spores, the spore color, and the structure of the peridium are all different from described species".

Genea klotzschii Berk. & Broome

In mixed woods of pines and broadleaves: Santa Eulalia de Ronsana (Barcelona), J. Passolas (I.1988), GM-RG 11899 (dupl. in MA-Fungi 24851, det.: I. Arroyo).

Remarks.-

The morphology of the fruit-bodies is diagnostic (cf. CERUTI, 1960; MONTECCHI & LAZZARI, 1984a...) as well as the uniserial disposition of the ascospores, which are hyaline subglobose to broadly ovoid and frankly tuberculate, with two-sized sparse verrucae: the larger ones exceptionally reaching 6 µm in height (Figs. 18-22), and measure 32-38 x 30-33 µm (ornamentation excluded).



Figs. 18–22. *Genea klotzchii*, GM-RG 11899: Ascospores.

This species was originally recorded by CALONGE & al. (1985a) from the same locality as "*Hydnotrya tulasnei* (Berk.) Berk." Later, CALONGE & al. (1985b) described it more fully under *Genea klotzschii* Berk. & Broome extending its distribution to Valladolid.

Genea verrucosa Vitt.

Under *Quercus ilex* subsp. *ballota*: Priego de Córdoba (Córdoba), J. Gómez (IV.1988), GM-RG 11901 (dupl. in Herb. J. M. Trappe); Ibidem (10.III.1989), GM-RG 11901.

Remarks.-

Unlike to the former species (*G. klotschii*), the ascocarps -which are larger- exhibit a peridium several times invaginated -contrarily to Hawker's (1953:459) statement- which originates a cerebriform gleba with white "veins" (the hymenium) over which lies a black layer (the false epithecium) of features comparable to those of the peridial cells (Fig. 23). Dehiscence takes place by a circular pore, comparable to the opening of fruitbodies of *G. klotschii*. The spores, while maintaining the same form and arrangement in the asci, are smaller (:21-26 x (18-)19-23(-26) µm) and have homogeneous verrucae, which are denser and little prominent (<1 µm in height) (Figs. 24-28).

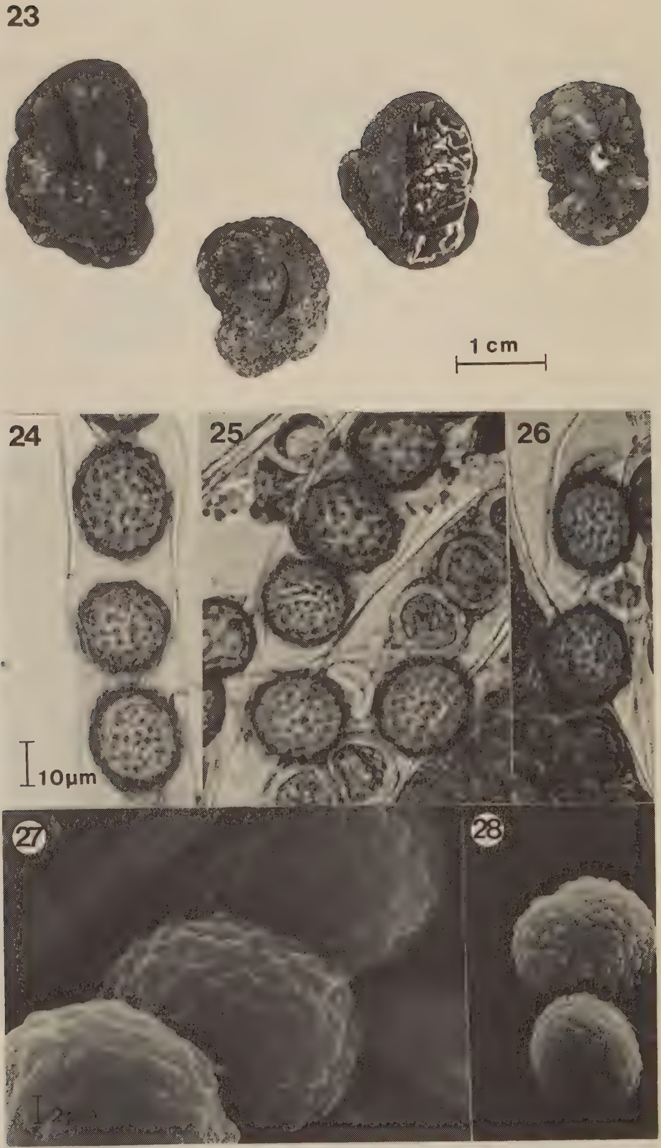
Regarding the differences with *G. sphaerica* Tul. & C. Tul., Prof. Trappe (pers. comm.) sent us the following information: "In *G. verrucosa* the warts on spores are conical or truncated, no broader than tall; In the closely related *G. sphaerica*, the warts are rounded, as broad or even broader than tall. Also, the paraphyses on *G. sphaerica* have inflated cells, those on G. verrucosa have cylindrical cells".

Up to the present, this species has been only cited once from the province of Toledo, in similar ecological conditions (ARROYO & al., 1989).

Geopora arenicola (Lév.) Kers

= *G. arenosa* (Fuck.) Ahmad

In clayish soils, among mosses, under *Pinus halepensis*, Valladolid, M. Ladero & G. Moreno (20.XI.1987), GM-RG 11921.


23
1 cm
24
25
26
10µm
27
28

Figs. 23–28. *Genera verrucosa*, GM-RG 11900: Fig. 23. Sporocarps; Figs. 24-28. Ascospores.

Remarks.-

This record broadens the already extensive list of Spanish provinces from which the species has been cited, and recently compiled by ARROYO (1990).

Geopora cooperi Hark.

In humus of *Quercus ilex* subsp. *ballota* and *Juniperus oxycedrus*, Hoyo de Manzanares (Madrid), W. Gams, 22.IV.1988, GM-RG 11062.

Remarks.-

With this record we extend the distribution of the species in Peninsular Spain. In this case it is the first record for the province of Madrid. Previously it had been catalogued from Granada and Guadalajara (MORENO & al., 1986), and more recently from Alava (MENDAZA & DIAZ, 1987) and Murcia (HONRUBIA & al., 1990).

Geopora nicaensis (Boud.) Torre

In basic soils under *Juniperus thurifera* and *Quercus ilex* subsp. *ballota*, Tamajón (Guadalajara), G. Moreno & M. Heykoop (19.XI.1986), GM-RG 11920.

Remarks.-

As in the previous cases, the chorology of the species in Spain is extended, since until now it was restricted to Madrid, Barcelona and Granada (MORENO & al., 1986) and Almería (CALONGE & ORIA DE RUEDA, 1988).

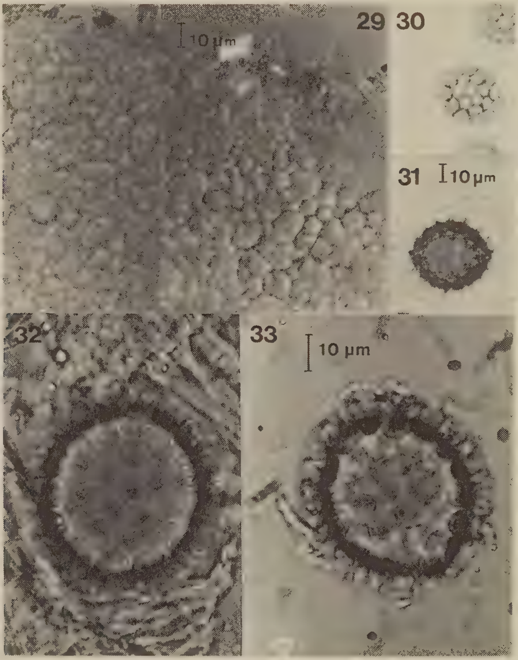
Tuber asa Tul. & C. Tul., Fung. Hypog.: 149, tab. 5, fig 2 (1851).

Growing together with *Choiromyces magnusii* in slate soil, Herreruela, Sierra de San Pedro (Cáceres), J. Espárrago (I-V-1988), GM-RG 11049; in acid heaths of *Cistus ladanifer*, together with *Terfezia arenaria*, Tejeda del Tietar (Cáceres), A. Corrales (20.IV.1984), GM-RG 11050; habitat not given, Adoufe-Brión (La Coruña), L. Cabo Rey (10.IV.1981) dupl. in GM-RG 11516; in slate soil, together with *Choiromyces magnusii* among *Cistus ladanifer*, Lobón (Badajoz), J. Espárrago (8.V.1989), GM-RG 11911.

Description.-

Ascocarps subglobose to irregular, not cavernous (not even at the base), up to 25 mm diam. with several external folds and protuberances, surface (sub)smooth and ochraceous. Gleba with fuscous-fleshy hues, interrupted by narrow, white, irregular discontinuous veins, that irradiate from a sligtly distinct columella that runs from the base of the fruit-body upwards towards the center and takes the shape of a few mycelial chords at the base. Odour not distinct.

Asci cylindric to club-shaped, constantly pedicellate, typically with 1-2(-3) spores. Ascospores spherical or, more regularly subsphaerical, yellowish fuscous, regularly reticulate, 34-50(-55) x 34-48 µm (Figs. 30-33) the meshes between 5 and 10 µm.



Figs. 29–33. *Tuber asa*: Fig. 29. Cross-section of the peridium (GM-RG 11049); Figs. 30-31. Typical citriform ascospores (GM-RG 11516, 11049); Figs. 32-33. Reticulate surface of the spores (GM-RG 11049).

Remarks.-

The species differs from other truffles by its yellowish or ochraceous smooth or subpubescent, regularly gibbose and exteriorly furrowed fruit bodies. The most striking microscopic feature are the 1-3 spored asci and particularly, the very pigmented, subglobose ascospores with complete, very regular alveoli with an hexagonal base. Another striking feature is that at both poles of the spore (coinciding with the longest axis) slight evaginations may be observed, that confer it a citriform aspect, as illustrated by CERUTI (1960).

It is close to *Tuber excavatum* and *T. foetidum*; the former with fruitbodies having a distinctly excavated base, a darker peridium and asci containing up to six widely ellipsoid spores, and the latter -also recorded from Spain- with externally dirty reddish, granulose (or even verrucose) fruit bodies, that have a nauseating odour, and ellipsoid, reticulate spores. Finally *Terfezia oligosperma* Tul. & C. Tul.=*Tuber oligospermum* (Tul. & C. Tul.) Trappe may be mistaken macroscopically with the present species, although it has globose-pyriform (not cylindric) asci and regularly spherical reticulate spores, and the peridial layer is filamentous (L. & G. RIOUSSET, 1990) and not pseudoparenchymatic as in *T. asa* (Fig. 9). Also, *T. borchii* Vitt. (=*T. albidum* Pico)recorded several times from Spain, shares this last feature, but has non pedunculate asci and comparable spores, with the exception of the ellipsoid-subglobose shape (MONTECCHI & LAZZARI, 1987).

CASTRO & FREIRE's (1982) record of "*Terfezia oligosperma*"should correspond in our opinion to *Tuber asa*; this collection although scant (at present merely reduced to powder), has perfectly mature and very coloured spores, whose size, shape and ornamentation undoubtedly belong to those of the specimens from Cáceres afore mentioned. So, after having studied material available of "*Terfezia*" *oligosperma* and being unable to do likewise with *T. berberiodora* on account of its poor condition (GM-RG 11917) -CASTRO & FREIRE, 1982- we conclude that both species ougth to be excluded from the "Provisional Catalogue of hypogeous fungi" published by CALONGE & al. (1985a).

This is the first record of this taxon from Spain, although its distribution is circunmediterranean.

Tuber aestivum Vitt.

In chalky soil, under *Quercus ilex* subsp. *ballota*, Priego de Córdoba (Córdoba), J. Gómez (IV.1988), GM-RG 11908.

Remarks.-

It is a species easy to identify by its externally black ascocarps with a peridium organized in thick pyramidal scales and a whitish gleba. The spores are dirty brown, broadly ellipsoidal and distinctly reticulate, with meshes up to 4 mm high and uneven size, 25-45 x (23-)28-32(-35) µm (Figs. 29-31).

Finally, the asci are oligosporic (1-5 spores), which enables its separation from *Tuber malençonii* Donadini, Riousset & Chevalier (LAZZARI & MONTECCHI, 1985). According to some authors (e. gr.: MONTECCHI & LAZZARI, 1984b), *T. mesentericum* Vitt. might be only a variety of *T. aestivum* from which it differs by the macroscopic and organoleptic characters of the fruitbodies. On the other hand *T. uncinatum* Chatin deserves an identical consideration. Thus Mr. L. Riousset (pers. comm.) states: "*T. uncinatum* serait tout simplement un *T. aestivum* qui arriverait à maturité compléte, ce qui pourrait alors expliquer la coleur plus foncé de sa gléba, la dimension plus élevée de la hauteur des alvéoles sporiques (développment de l'ornamentation arrivé à son terme) et surtout son apparition plus tardive et aussi sa présence dans des régions septentrionales où le climat est moins chaude, plus humide".

Its known distribution in peninsular Spain is relatively broad, although it appears restricted to the northern half: Barcelona, Gerona and Soria (ARROYO, 1990, who also records it from Mallorca).

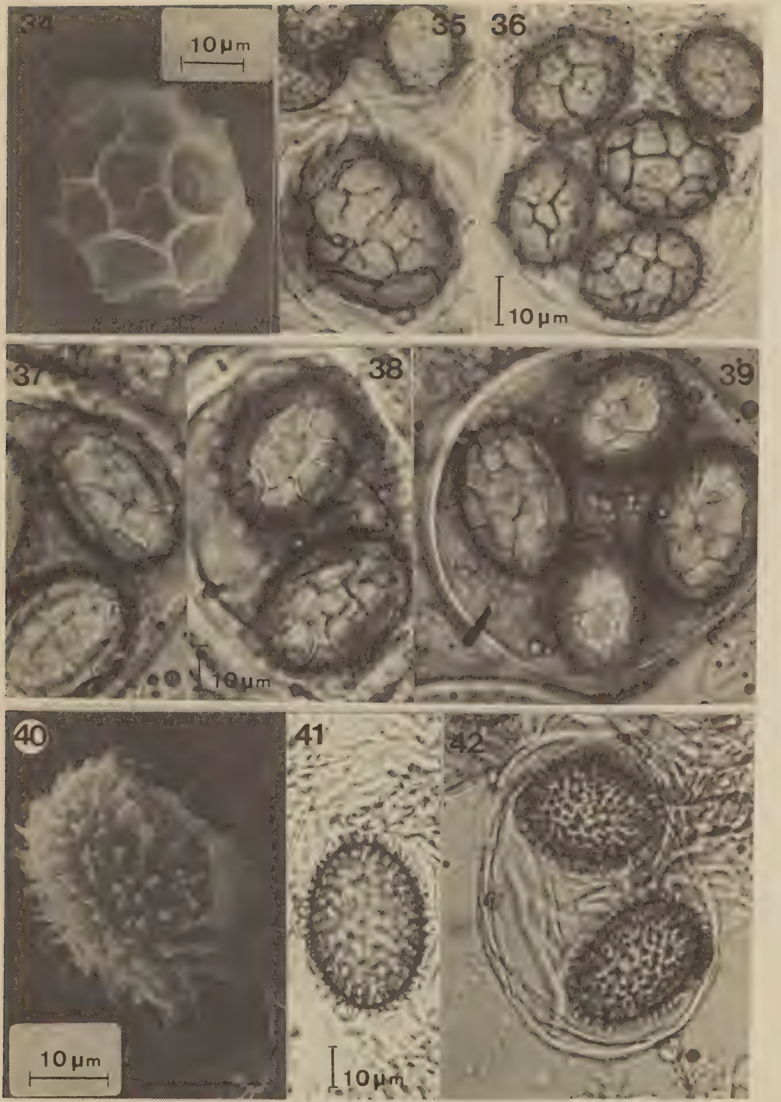
Tuber excavatum Vitt.

In basic soil, under *Quercus ilex* subsp. *ballota*, Priego de Córdoba (Córdoba), J. Gómez (25.VI.1989), GM-RG 11907, 11910.

Remarks.-

The most outstanding features of the species are: the ascocarps of horny consistency, externally more or less furfuraceous and ochre, excavated at the base; the asci are oligosporic (1-4 spores) and the ascospores broadly ellipsoid with crests (ca. 3µm high) forming a complete reticulum of wide and irregular meshes, 27-43 x 25-30 µm (ornamentation excluded) - Figs. 37, 38 & 39-.

The same species has been adequately described and photographed by MONTECCHI & LAZZARI (1984b).


34
10 µm
35
36
10 µm
37
38
10 µm
39
40
10 µm
41
10 µm
42

Figs. 34–42. Asci and ascospores: Figs. 34-36. *Tuber aestivum* (GM-RG 11908); Figs. 37-39. *Tuber excavatum* (GM-RG 11910); Figs. 40-42. *Tuber nitidum* (GM-RG 11906).

T. excavatum has only been recorded once from Spain by CALONGE & al. (1985a); from the province of Barcelona although its spores under SEM have narrower and homogeneous meshes (CALONGE & al., op. cit.:49, fig. 4)that do not coincide with the traditionally accepted concept of this species.

Tuber nitidum Vitt., Mon. Tub.: 43, tab. 2, fig. 10 (1831).

Under *Quercus ilex* subsp. *ballota*, Priego de Córdoba (Córdoba), J. Gómez (IV.1988), GM-RG 11906.

Description.-

Ascocarps more or less globose, slightly deformed, with a slightly depressed base (excavated), of reduced diameter (ca. 15 mm diam.). Peridium yellowish, subpubescent, not separable, hard (partially gelatinized) and textura "intrincata-epidermoidea"; columella arborescent and arachnoid, white, hardly contrasting with the pale yellowish colour of the hymenium.

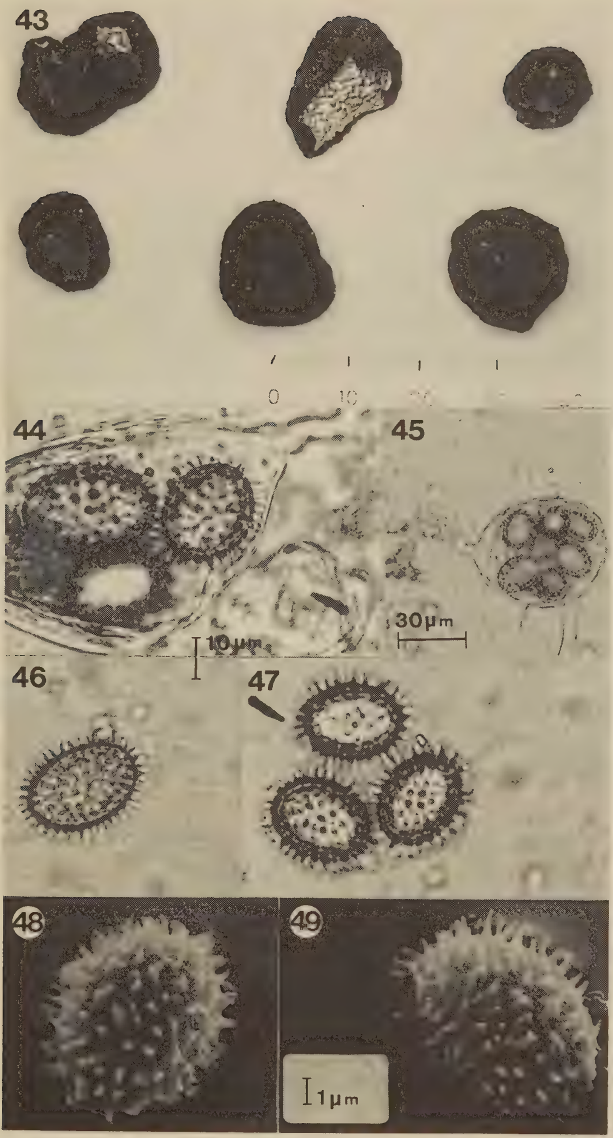
Asci more or less globose, pedicellate (55 µm diam.) regularly 1-4 spored. Ascospores broadly ellipsoid, ochraceous, densely spiny, 23-40 x 21-30 µm, excluding the spines (which reach 3-5 µm high) -Figs. 40, 41 & 42-.

Remarks.-

This species, unknown so far from Spain, differs mainly from *T. rufum* by its macroscopic features, such as the smaller size of the fruitbodies, its lighter coloured and more fragile peridium, as well as by its non cracked surface and less coloured gleba (CERUTI, 1960; MONTECCHI & LAZZARI, 1984b, 1988a). Thus many authors have considered it a simple variety of *T. rufum*. Microscopically both taxa are very similar, particularly in the spore features.

Tuber panniferum Tul. & C. Tul., Giorn. Bot. Ital. 2:62 (1845).

Under *Quercus ilex* subsp. *ballota*, Priego de Córdoba (Córdoba), J. Gómez (30.IV.1989 & 25.IV.1989), GM-RG 11905 & 11904.


43
0
10
44
45
30µm
10µm
46
47
48
49
1µm

Figs. 43–49. *Tuber panniferum*, GM-RG 11904: Fig. 43. Sporocarps showing the hairy surface and the cerebriform gleba; Figs. 44-45. Asci and spores; Figs. 46-49. Ascospores.

Description.-

Ascocarps globose, more or less regular, 1.5-3 cm, externally dark dirty brown and distinctly lanuginose. Gleba compact, whitish (turning ochre with time) permeated by numerous white veins (Fig. 43).

Peridium pseudoparenchymatic ("textura epidermoidea-subangular"); hairs long, pluriseptate (500 x 4-10 µm), thick-walled, dirty brown, somewhat flexuose. Asci subglobose to pyriform, pedicellate (50-75 µm), containing 3-8 spores (Figs. 44-45); Ascospores broadly ellipsoid, dirty-yellowish, densely spiny, 21-33(-42) x 15-23(-26) µm, excluding the ornamentation consisting of narrow, more or less conical spines (with a narrow base and reaching 3-4 µm high) -Figs. 44-49-.

Remarks.-

This species stands out among similar species by the abundance of hairs emerging from the peridium in a manner recalling *Geopora cooperi*. The basal pit to which TULASNE & TULASNE refer (1851:143) is not obvious in all fruit bodies and thus should not be taken as an outstanding feature, whereas according to these authors, its consistency and internal structure extraordinarily recall *T. rufum*.

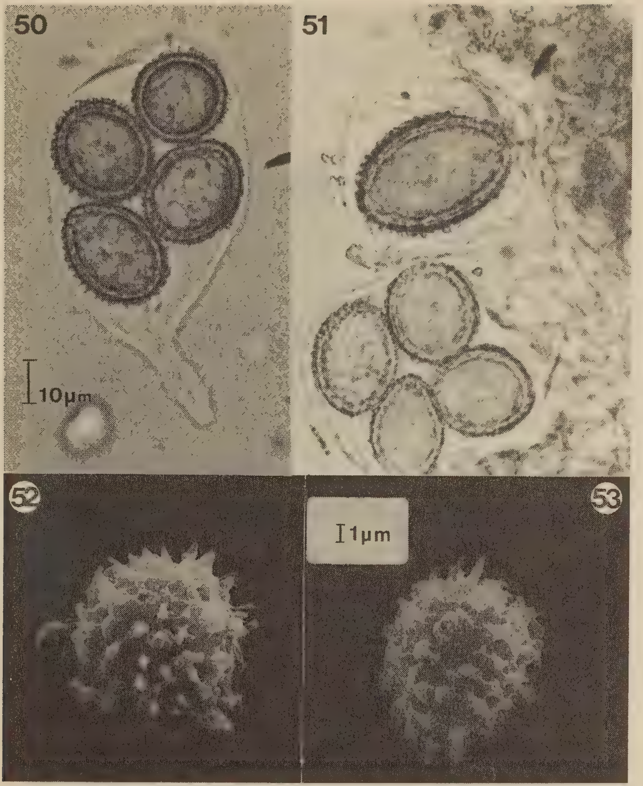
Its world distribution is quite uncertain, and was described from France and now is recorded from Spain. We do know of other finds.

Tuber rufum Pico: Fr.

In wood of *Castanea sativa*, Sierra de Bernabé del Piornal de Tormantós (Cáceres), A. Montecchi & al. (11.XI.1987) GM-RG 11053; mixed woods of pines and broad leaves, Santa Eulalia de Ronsana (Barcelona), J. Passolas (I.1988), GM-RG 11909 (dupl. in MA-Fungi 25122).

Remarks.-

The spore ornamentation consists of long spines (≤3 µm long.) with a narrow base and acute point, straight often curved at the apex , always independent and never united at the apex, contrarily to the statement of CALONGE & al. (1977) and may merely touch each other as a consequence of their proximity and sometimes curved apices (Figs. 50-53).

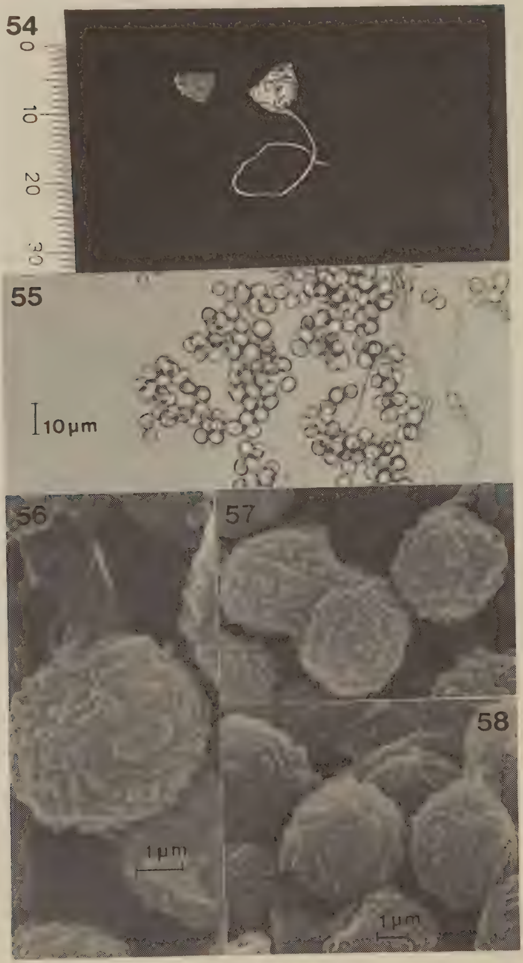


Figs. 50–53. *Tuber rufum*, GM-RG 11053: Figs. 50-51. Asci and spores; Figs. 52-53. Electron photomicrograph of the ascospores.

According to MONTECCHI & LAZZARI (1988a), this species may be distinguished macroscopically from *T. ferrugineum* Vitt. by the horny-yellowish nature of the peridium. Its differences with *T. nitidum* have already been stated.

Up to the present, this truffle has been found in Spain only in rare occasions, in the province of Cuenca (CALONGE & al., 1977) and Barcelona (CALONGE & al., 1985a; CALONGE & al., 1985b) living under species of *Quercus*, *Corylus* and *Pinus* (in mixed woods). Our record from Cáceres confirms a broader distribution, besides a new habitat (*Castanea*) unknown for the species from Spain and apparently unknown in the rest of the world, otherwise connected mycorrhizically with a host of trees, both perennial and broadleaved (CERUTI, 1960).

Gastrosporium simplex Matt.


54
0
10
20
30
55
10µm
56
1µm
57
58
1µm

Figs. 54–58. *Gastrosporium simplex*, GM-RG 11515: Fig. 54. Sporocarp; Fig. 55. Basidiospores and capillitium threads; Figs. 56-58. Electron photomicrograph of the basidiospores.

In communities of *Arrhenathero-Stipetum tenacissimae* reimplanted with *Pinus halepensis*, in greyish-chalky soils: Cuesta Zulema, Alcalá de Henares (Madrid), J. Pavón & J. Diez (5.II.1988), GM-RG 11514; Ibidem, G. Moreno & al. (26.I.1989), GM-RG 11515.

Remarks.-

This species, of circummediterranean distribution (MALENÇON & BERTAULT, 1971) has previously been recorded from Spain three times: once from Puerto de Almansa (MALENÇON & BERTAULT, op. cit.) and twice in different localities of the province of Madrid (CALONGE & al., 1977; CALONGE & al., 1985a). In all cases it was found in basic soil and arid zones, areas little studied by Spanish mycologists reason for which-added to the semi- hypogeous and very small size (0.5-1.5 cm diam.) of the fruitbodies, it may have been easily overlooked. However, it may be recognized without difficulty by its long basal mycelial chord, its filamentous exoperidium, coated by a pure white and fugacious pruina (crystals of Ca oxalate) under which a tenacious and strongly jellyfied peridium may be observed, enclosing a homogeneous and pulverulent (at maturity), olive-green to completely cream-coloured gleba, formed by pale yellowish spores (:3.7-5.5 x 3.5-4.5 µm) of varied morphology (sphaerical, subglobose to amygdaliform), subtle undulate surface, mixed with occasional pluriseptate hyaline, elastic and scantily branched capillitial threads (Figs. 54-58).

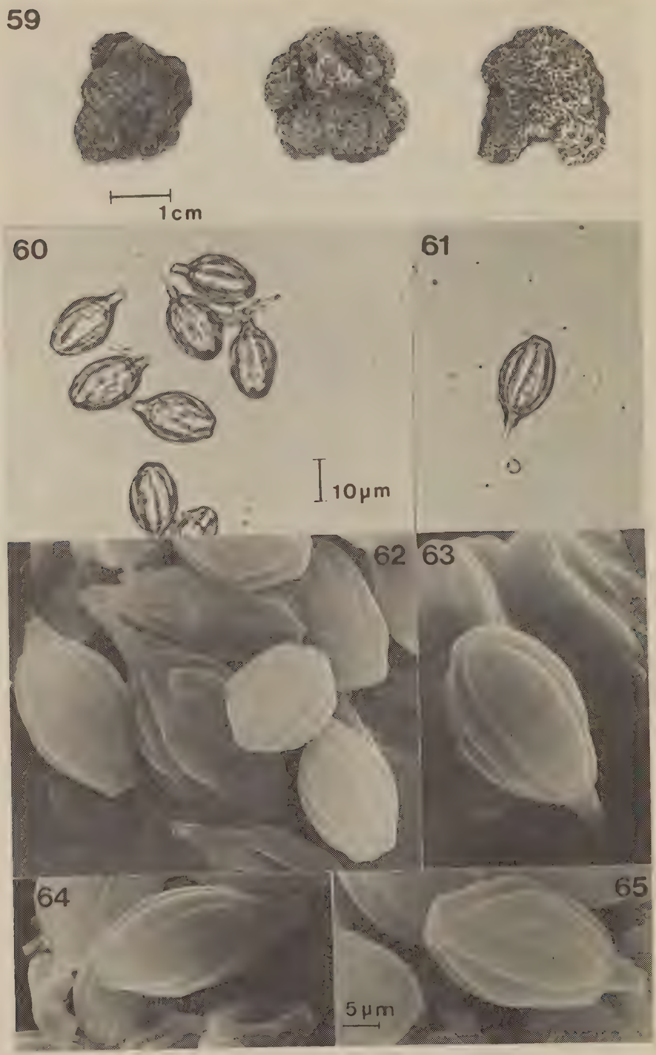
Gautieria morchellaeformis Vitt.

In sandy-chalky soil, under *Quercus ilex* subsp. *ballota*, Priego de Córdoba (Córdoba), J. Gómez (11.V.1989), GM-RG 11888.

Remarks.-

Numerous more or less globose to irregular almost superficial basidiocarps were found on this occasion, measuring up to 4 cm diam., without peridium (evanescent at maturity) with a powdery, ferruginous gleba contained in numerous labyrinthiform chambers, white-walled and with a cartilaginous texture (Fig. 59). Microscopically the most striking feature are the ellipsoid, shortly pedicellate, dirty-yellowish, basidiospores, ornamented with a few ridges (delimiting furrows) of rounded margin and 18-23 x 11-17 µm excluding the ornamentation and remains of the sterigma) -Figs. 60-65-.

The species was previously known from Spain, from Lérida (CALONGE & al., 1977), Cuenca (CALONGE & ARROYO,


59
1cm
60
61
10µm
62
63
64
65
5µm

Figs. 59–65. *Gautieria morchaelliformis*, GM-RG 11888: Fig. 59. Basidiocarps; Figs. 60-65. Electron photomicrograph of the basidiospores.

1987) and Barcelona (AYMERICH & LLIMONA, 1986) normally associated with conifer woods.

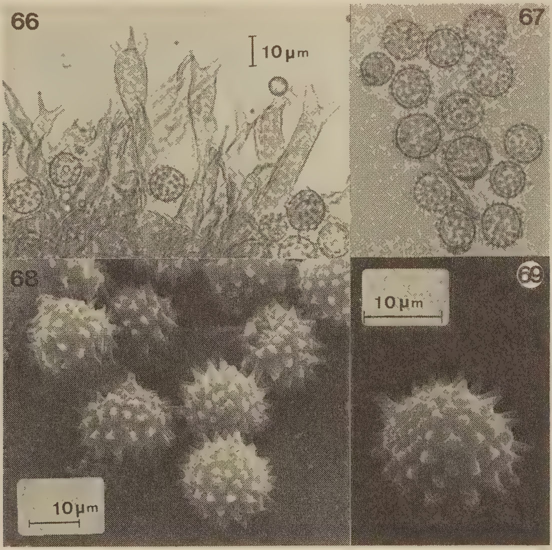
Hydnangium carneum Wallroth

Under *Eucalyptus* sp., La Herrería (Badajoz), F. González, GM-RG 11891.

Remarks.-

It has subglobose basidiocarps, sometimes with a basal protuberance, 1-2.5 cm diam. Peridium thin, externally fleshy-pink and labyrinthiform concolorous gleba. Microscopically subcylindric, predominantly bisporic basidia may be observed (Fig. 66) with hyaline to pale yellowish, sphaerical basidiospores (10-16 µm diam.), ornamented with distinct conic, acute spines, 2-3 µm high (Figs. 67-69).

The phylogenetic *Hydnangium-Laccaria* (*Tricholomataceae*), relationship, several times noted, is considered universally accepted.



Figs. 66–69. *Hydnangium carneum*, GM-RG 11891: Fig. 66. Basidia; Figs. 67-69. Basidiospores.

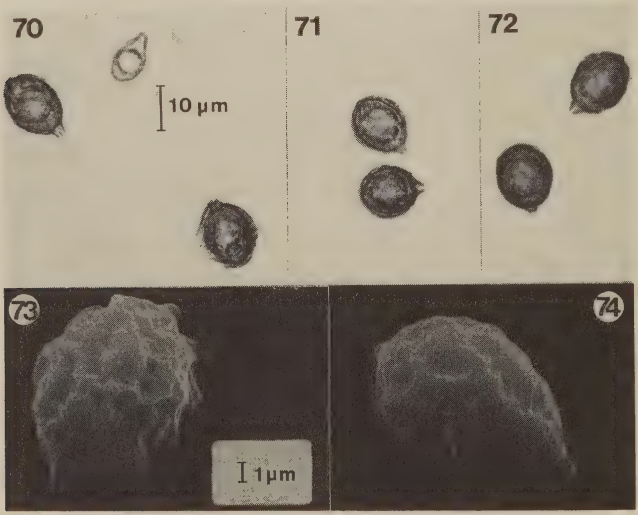
Although this species had been recorded originally from Canary Islands (WILDPRET & al., 1972) only recently it has been recorded from peninsular Spain, from La Coruña (JEPPSON, 1987) and Gerona (ANONYMOU, 1987) always mycorrhizically related to *Eucalyptus* spp.

Hymenogaster cerebellum Cavara, Fungi Longobardiae exicc. nº 109 (1893).

Under *Quercus pyrenaica*, Sierra de Bernabé del Piornal de Tomantós (Cáceres), A. Montecchi & al. (11.XI.1987), GM-RG 11068.

Remarks.-

The most striking features of this species are the beautiful dark brown, oval, uniguttulate shortly pedicellate basidiospores (1.2-2.5 µm diam.) provided with a more or less distinct apical papilla (recalling a lemon); on the other hand the densely verrucose epispore is overlaid by a delicate, hyaline and rugose perispore, measuring 12.6-15.5(-16.7) x 9.3-11.2 µm (excluded the basal apiculum) -Figs. 70-74-.



Figs. 70–74. *Hymenogaster cerebellum*, GM-RG 11068: Basidiospores.

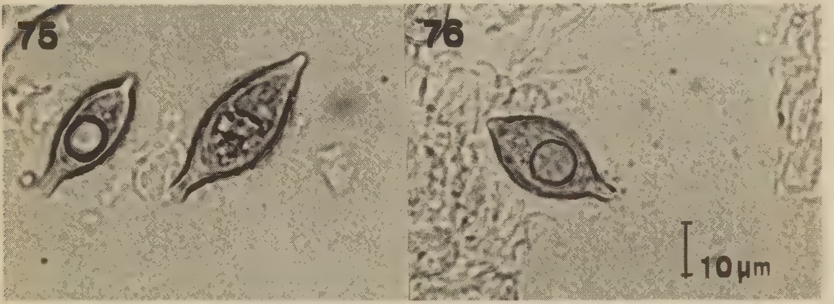
From among the 70 odd recognized species in the "controverted" genus *Hymenogaster* (SOEHNER, 1962) only 8 have been reported from Spain up to the present (CALONGE, 1990), including our find of *H. cerebellum* -apparently known only from Italy (SVRCEK, 1958)- which is a new record from Spain.

Hymenogaster citrinus Vitt.

Under *Quercus ilex* subsp. *ballota*, Priego de Córdoba (Córdoba), J. Gómez (4.V.1989), GM-RG 11887.

Remarks.-

As occurs with the rest of the species within this genus, the morphology, ornamentation and size of the basidiospores are of diagnostic value. In this case they are ellipsoid-citriform, distinctly mammose at the apex and prolongued in a basal pedicel (remains of the sterigma), yellow-ochraceus, with a loose perisporium which is more or less festooned or undulate and hyaline, 18-26 x (10-)12-14.8 µm (excluded the apiculum) -Figs. 75-76-.

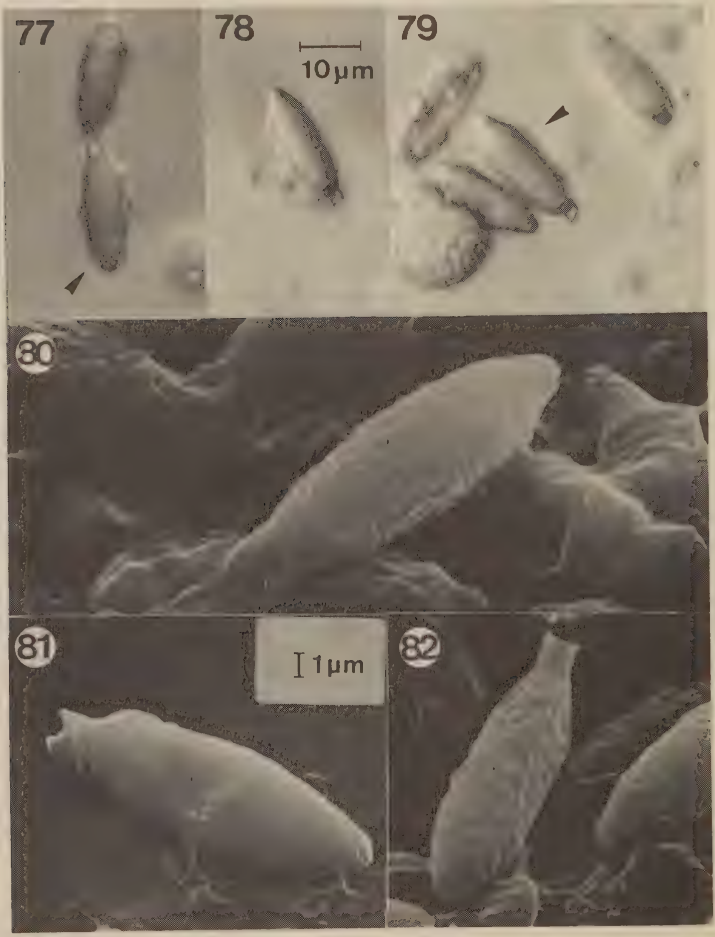


Figs. 75–76. *Hymenogaster citrinum*, GM-RG 11887: Basidiospores.

Only HEIM & al. (1934) accounted for the presence of this species in Spain, from the province of Lérida. Thus our record confirms its presence in Spain and broadens its distribution.

Hysterangium stoloniferum Tul & C. Tul. var. *rubescens* (Quélet) Zeller & Dodge, Ann. Missouri Bot. Gdn. 16:111 (1929).

In humus of *Castanea sativa*, Sierra de Bernabé del Piornal de Tomantós (Cáceres), A. Montecchi & al. (11.XI.1987), GM-RG 11066; Under *Quercus ilex* subsp. *ballota* in clayish-chalky soil, Priego de Córdoba (Córdoba), J. Gómez (10.V.1989), GM-RG 11889.



Figs. 77–82. *Hysterangium stoloniferum* var. *rubescens*, GM-RG 11066: Basidiospores.

Remarks.-

Macroscopically the basidiocarps are characterized by having a thick, white rhizomorph, from whence irradiates internally a white, branched columella that contrasts with the greenish-olive gleba, as well as by their white, pseudoparenchymatic peridium, the reddens upon the slightest touch. Microscopically, the basidiospores are yellowish, ellipsoid-fusoid, shortly pedicellate at the base and with a rugose perispore and relatively large size (:16.7-21 x 6.2-8 µm) -Figs.77-82-.

The present taxon had not been recorded as yet from the Iberic Peninsula. According to SVRCEK (1958) it has been recorded in Europe from Czechoslovakia, USSR and Germany (GROSS & al., 1980).

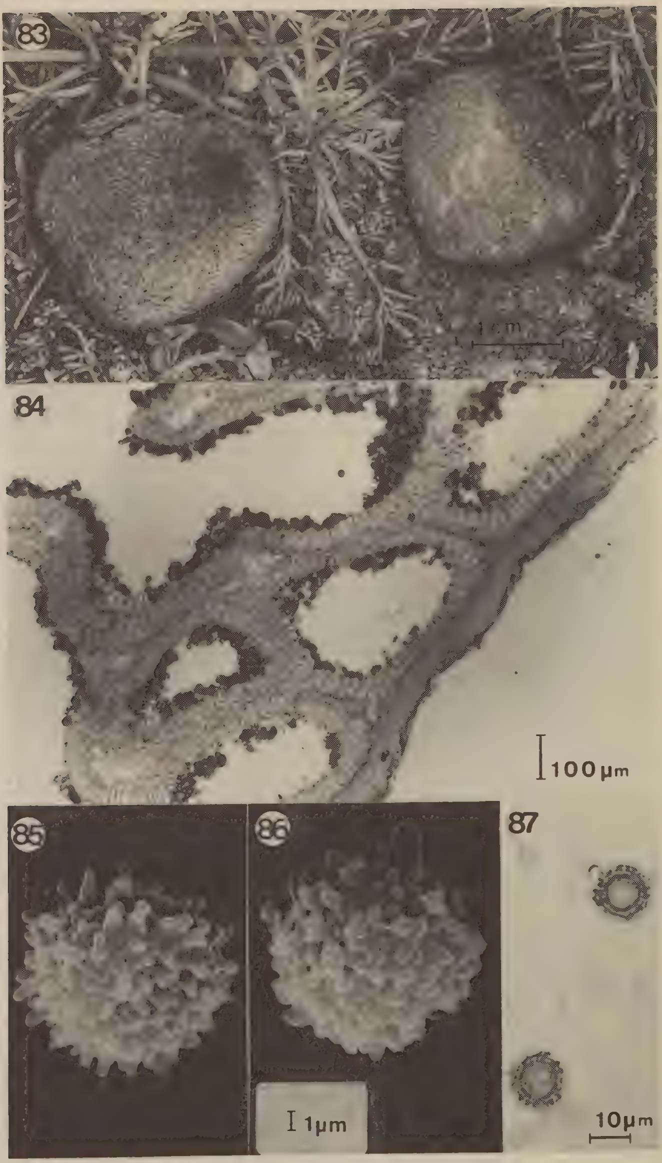
Martellia mediterranea Moreno, Galán & Montecchi *sp. nov.* (Figs 83-94).

Basidiocarpo globoso vel subgloboso, usque ad 2.2 cm. diam., fusco-rubro ("Russus A2d", LOCQUIN, 1975) rugoso. Gleba in maturitate concolora, labyrinthica, in alveolis irregularibus, 0.1-1 mm diam., ad trabes tenuis hymenophoris instructa. Peridio cohaerentibus, tenui, 75-100 µm crass., unistratificato, hyphis dense intrincatis, sphaerocystis rarioribus, in vivo inseparabile, in sico protracto. Subhymenio celluloso, fibulis adsunt. Basidiis claviformibus vel cylindricis, 40-48 x 11-15(-17) µm, 1-4-sporis, cum cystidiis cylindricis, capitatis, sulphobenzaldehydo +, 45-50 x 7-11 µm alternantibus. Sporis subsphaericis, 10 x 8 µm, ochraceis, uniguttulatis, apiculatis, dense spinosis, amyloideis.

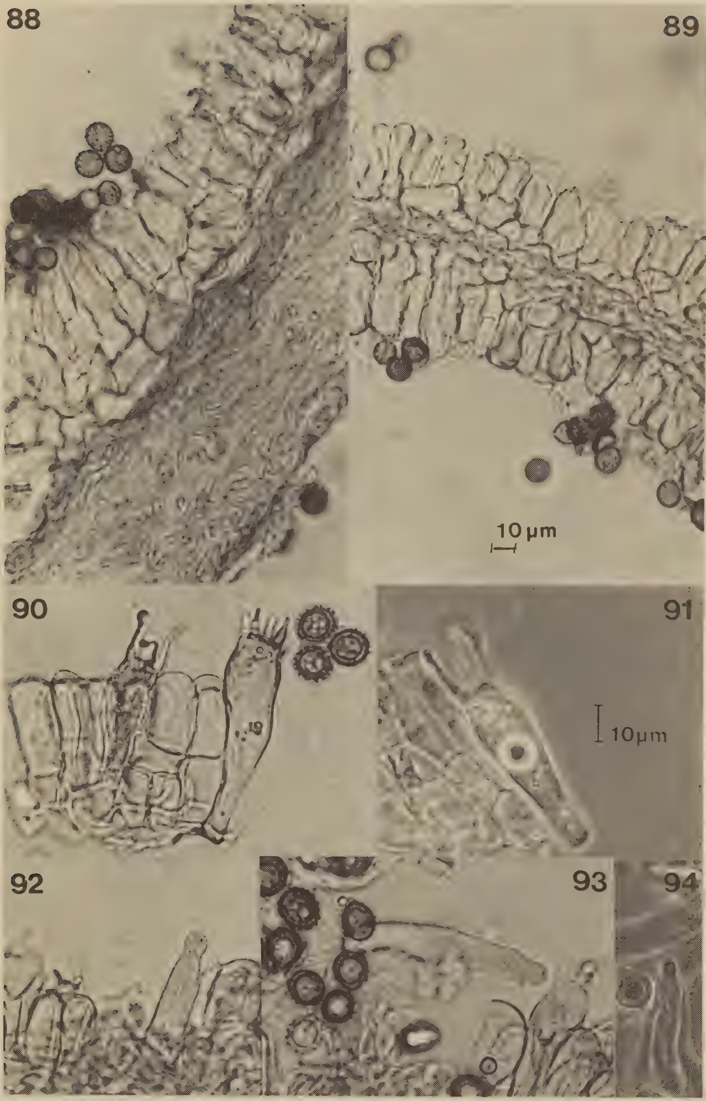
Holotypus: Hispania, Cáceres, Parque de Monfragüe, leg. A. Montecchi, J. L. Manjón, R. Galán & G. Moreno, 9.XI.1987, ad Quercus suber et Cistus ladanifer, in solo sabuloso acido, in Herb. GM-RG 11057 conservatus est. Isotypis in herb. Montecchi, Trappe et MA-Fungi.

Basidiocarps globose to subglobose, up to 2.2 cm diam., externally dirty-reddish ("Russus A2d", LOCQUIN, 1975), rugose. Gleba concolorous at maturity, labyrinthiform with irregular alveoli, 0.1-1 mm diam. with thin walls sustaining the hymenium (Figs. 83-84).

Peridium very coherent, thin, 75-100 µm thick, unistratified, formed by densely woven hyphae and occasional sphaerocysts, oriented parallel to the surface (Figs. 84, 88), difficult to separate when fresh but easily so when dry. Subhymenium cellular (Figs. 88, 89). Clamps not observed. Basidia claviform to cylindric, 40-48 x 11-15(-17) µm, 1-4 spored (Figs. 90-91), occasionally alternating with more or less cylindric, capitate, sulphobenzaldehyde + cystidia, 45-50 x 7-11 µm (Figs. 92-94). Spores subspherical, (8.5-)9-11(-12) µm or, more


83
1 cm
84
100 µm
85
86
1µm
87
10µm

Figs. 83–87. *Martellia mediterranea* Moreno, Galán & Montecchi, holotypus: Fig. 83. Basidiocarps; Fig. 84. Cross-section of a sporocarp under light microscope; Figs. 85-87. Basidiospores.


88
89
10 µm
90
91
10µm
92
93
94

Figs. 88–94. *Martellia mediterranea* Moreno, Galán & Montecchi, holotypus: Fig. 88. Peridium, subhymenium and hymenium; Fig. 89. Trama; Figs. 90-91: Basidia; Figs. 92-94. Cistidia.

rarely ellipsoid, 10 x 8 µm, ochraceous, uniguttulate, apiculate, densely spiny, amyloid (Figs. 85-87).

In sandy acid soils with *Quercus suber* L. and *Cistus ladanifer* L.: Finca Las Cansinas, Parque de Monfragüe (Cáceres), A. Montecchi, J. L. Manjón, R. Galán & G. Moreno (9.XI.1987) GM-RG 11057 Holotypus (Isotypes in Herbs. J. M. Trappe, A. Montecchi & MA Fungi).

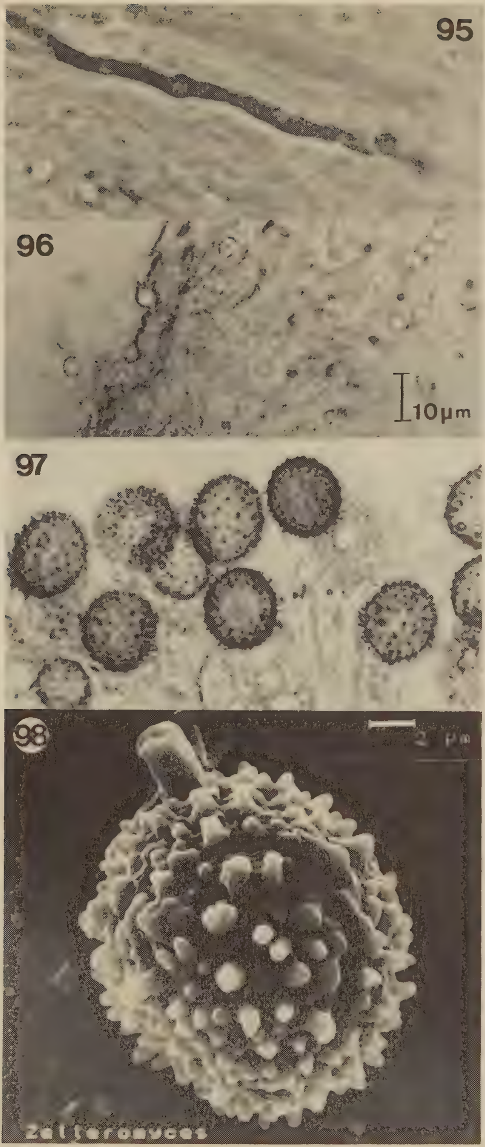
Remarks.-

Judging from the frequency of collection of the basidiocarps of this species, it would appear to be a very common fungus in all the region studied, although it passes unnoticed because the fruit bodies never appear above the ground, living at a depth of 8-18 cm and exhaling a very fruity odour, so that they were in all cases found by the specially trained dog of A. Montecchi.

The basidiocarps of this species are strikingly similar macroscopically with *Zelleromyces stephensii* (Berk.) A. H. Smith -taxon which has been monographed by MILLER & MILLER (1986)- excepting that the latter have abundant lacticiferous hyphae (not observed in *Martellia mediterranea*) both in the trama and the peridium (Fig. 95), which secrete a bright yellow-latex upon sectioning. Under the LM other differential characters may be observed such as the larger width and substantial gelification of the peridium (Fig. 96), larger size, i. e. 9.5-16(-18) x 8.4-13.5(-15.5) µm, lighter colour, different ornamentation and tendency to become ellipsoid of the basidiospores (Figs. 97-98) and lastly, absence of cystidia in the hymenium in *Z. stephensii*.

One must not forget that the number and delimitation of "gastroid" genera and species assigned to *Russulaceae* is uncertain (SINGER & SMITH, 1960; PEGLER & YOUNG, 1979; MILLER, 1989; ZHANG & YU, 1990...), so we contacted Prof. J. M. Trappe who, upon confirming that ours specimens represented an undescribed taxon, stated that: "This specimen has scattered sphaerocysts in the inner peridium, which makes it to close to *M. mistiformis* Matt. The sphaerocysts are erratic, so none may appear in some sections. Also, they often don't rehydrate well and thus can be overlooked in dried material, but in this specimen flaming the KOH mount with a match until boiling rehydrated them nicely. It differs from *M. mistiformis* by its smaller spores, thinner spore ornamentation, and esentially 1-layered peridium. (I have examined the holotype of *M. mistiformis* at Torino and the isotype at Farlow; for sure your collection is different)."

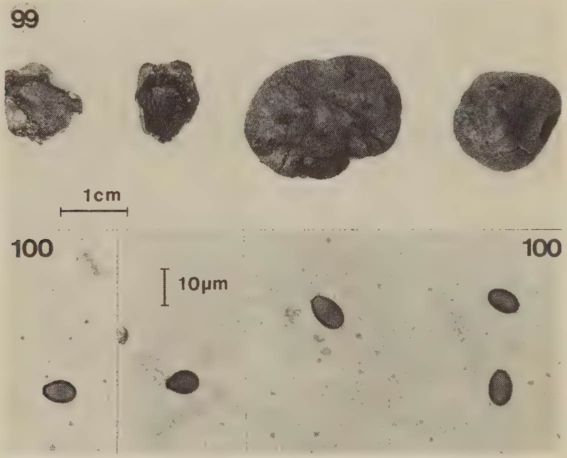
Contrary to the statment of CALONGE (1990), *Zelleromyces stephensii* has not been recorded as such, from Spain.


95
96
10μm
97
98
2 μm
Zelleromyces

Figs. 95–98. *Zelleromyces stephensii*, H. A. Montecchi 715/155, Italy. Fig. 95. Lactiferous hyphae from the peridium; Fig. 96. Texture of the peridium; Figs. 97,98. Basidiospores.

Melanogaster variegatus (Vitt.) Tul & C. Tul, Ann. Sci. Natur. Bot. sér. II, 19:378, tab. 17, fig. 22 (1843).

In humus of ***Arbutus unedo*** and ***Quercus suber*** L.: Sierra de la Umbría, Parque Natural de Monfragüe (Cáceres), G. Moreno & al. (13.III.1987), GM-RG 11051; habitat not given, Cáceres, C. Sendín GM-RG 11517; under ***Quercus ilex*** subsp. ***ballota***, Priego de Córdoba (Córdoba), J. Gómez (10.V.1990), GM-RG 11890.



Figs. 99–100. ***Melanogaster variegatus***: Fig. 99. Sporocarps (GM-RG 11890); Fig. 100. Basidiospores (GM-RG 11051).

Remarks.-

This taxon seems to be well distributed in the Spanish geography (CALONGE, 1990) although it would appear wise to omit the province of Albacete (Calonge, 1973) since several years later, the same material was identified as ***Melanogaster broomeianus*** (Berk. in Tul. & C. Tul.) Berk. emend. Zell. & Dodge by the same author (in CALONGE & DEMOULIN, 1975). A similar situation occurs with the records that CALONGE (1990) attributes to Gerona, since MAIRE (1937) and SINGER (1947) referred explicitly to ***M. broomeianus*** and not to ***M. variegatus*** s. s. The listing of SOBRADO-MAESTRO (1911) from La Coruña must be omitted because the author queries the record. We also ignore the source of the records from Barcelona (sic). Thus, ***M. variegatus*** appears to be restricted to Valencia and Guipúzcoa (LAZARO-IBIZA, 1912) and Mallorca (CALONGE & al., 1988). Recently, HONRUBIA & al. (1990) found it in the region of Murcia.

Besides *M. broomeianus*, another species of the same genus is known from Spain, viz *M. ambiguus* (Vitt.) Tul. & C. Tul. *M. variegatus* differs well from both species mainly by its basidiospores which never tend to become cylindric nor citriform (as in each one of the former, respectively), but are widely ellipsoid or oval and frequently asymmetric (Figs 99-100), measuring (5-)6.8-8.3 x (3.5-) 4.3-5 µm.

Octavianina asterosperma (Vitt.) O. Kuntze

≡ *Octaviania asterosperma* Vitt.

In chestnut wood, Sierra de Bernabé del Piornal de Tormantós (Cáceres), A. Montecchi & al. (11.XI.1987), GM-RG 11065.

Description.-

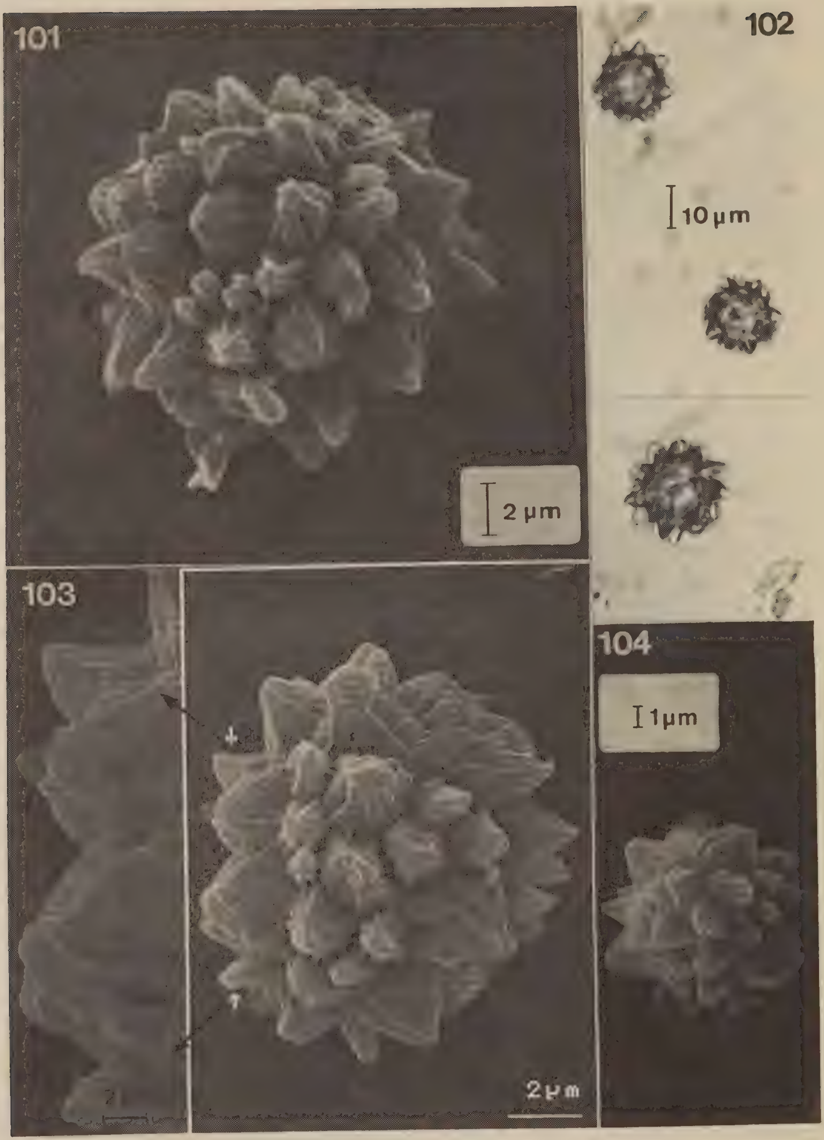
Basidiocarps subspherical, about the size of a hazelnut, externally white and smooth, but with flesh hues or even fuscous when old or upon the slightest contact with air; with obvious basal mycelial chords. Gleba at first white, fuscous ferrugineous when ripe, with numerous small, irregular loculi with very thin, papyraceous walls, occupied by the mass of spores fallen from the basidia. Columella pulvinate, scantily developed from which irradiate the former veins.

Spores spherical to subglobose, fuscous-yellowish, dextrinoid, 11-13.5 µm ϕ, with prominent pyramidal acute warts, up to 3 µm in height, formed as a consequence of the convergence of groups of single spines (Figs. 101-104).

Remarks.-

Acording to DEMOULIN (in Boud., Icon. Myc. V: 207, 1985) some authors consider that the present species cannot typify the genus *Octaviania*, and use the name *Octavianina asterosperma* as PEGLER & YOUNG (1979), MONTECCHI & LAZZARI (1988b)..., idea which Demoulin does not share. Without entering at this point into the discussion as to which of the two names is correct, we do wish to stress that it is the first record from Spain of a member of this genus although we have reports of its appearance in Catalonia (A. M. Paz Martín, personal comm.).

The geographic distribution of this species is typically central and middle European, having been found in France, Italy, Great Britain, Germany, Netherlands, Czechoslovakia, Denmark and now Spain. It is probably frequent in northern Africa having been recorded from


101
2 µm
102
10 µm
103
104
1µm
2µm

Figs. 101–104. *Octavianina asterosperma*, GM-RG 11065: Electron photomicrograph of the basidiospores.

Algeria. However its appearance in Nortn America is quite surprising (CASTELLANO & al. 1989).

ACKNOWLEDGEMENTS

We wish to express our deep gratitude to the following persons and institutions:

Prof. J. M. Trappe, who revised the samples of *Elaphomyces anthracinus*, *Genea verrucosa* and indicated the undescribed species; Dr. J. E. Wrigth for the revision, latin diagnoses and translation of the text into English; Mr. Louis Riousset, Dr. Luis Freire, Dra. Marisa Castro, Dr. Mario Honrubia, Mr. Gabriel Carrascosa and very particularly Mr. Javier Gómez for the loan or remittance of specimens from their respective herbaria. Special thanks are due Ms. V. Carnero and Mr. J. A. Esteban for their permanent cooperation.

To the Sociedad Hidroeléctrica Española S.A., and particularly Mr. Gonzalo Pérez and Mr. Enrique Pinto, for facilities at the Central Hidroeléctrica de Torrejón (Cáceres) during our mycological field trips.

To Mess. Nikon Co. (Rego & Cia., S.A., Madrid) for their advice with photography.

To the Ministry of Educación & Ciencia of Spain (C.I.C.Y.T.) for grant nº PA86-0063 for the research project: "Study or the Fungi that fructify in the Monfragüe (Cáceres) Natural Park".

LITERATURE CITED

ANONYMOUS (1987). *Bolets de Catalunya. VI.* Soc. Catalana Micol., Caixa de Barcelona.

ARROYO, I. (1990). *El orden Pezizales, Ascomycotina en España (Península y Baleares). Estudio crítico y sistemático.* Tesis Doctoral. Univ. Complutense, Madrid. 374 pp.

ARROYO, I., CALONGE, F. D., CARRASCOSA, G. & SAU, E. (1989). Nuovi funghi ipogei di Spagna III. *Hydnocystis clausa* (Tul.) Ceruti e *Genea verrucosa* Vitt. *Micol. Ital.* 1:3-7.

AYMERICH, J. & LLIMONA, X. (1986). *Gautieria morchellaeformis* al Berguedà (Catalunya). *Folia Bot. Misc.* 5:145.

CABALLERO-MORENO, A. (1990). *Hongos raros o interesantes en la Rioja.* Resúmenes XV Jonadas Internacionales de Micología, 10-14 Octubre, San Sebastián:38.

CALONGE, F. D. (1990). Check-list of the Spanish Gasteromycetes (*Fungi, Basidiomycotina*). *Crypt. Bot.* 2:33-55.

CALONGE, F. D. & ARROYO, I. (1987). Aportación al catálogo micológico de la provincia de Cuenca. *Bol. Soc. Micol. Madrid* 11:241-252.

CALONGE, F. D., & ORIA DE RUEDA, J. A. (1988). Aportación a la micoflora de la provincia de Almería. *Bol. Soc. Micol. Castellana* 12:93-106.

CALONGE, F. D., ROCABRUNA, A. & TABARES, M. (1985a). Nuevos datos sobre los hongos hipogeos de España. *Bol. Soc. Micol. Castellana* 9:45-54.

CALONGE, F. D., ROCABRUNA, A., TABARES, M. & RODRIGUEZ, N. B. (1985b). Nuevos datos sobre los hongos hipogeos de España. II. Géneros *Balsamia*, *Delastria* y *Genea*, novedades para el catálogo español. *Butll. Soc. Catalana Micol.* 9:57-64.

CALONGE, F. D., SIQUIER, J. L., CONSTANTINO, C. & LILLO, X. (1988). Contribución al conocimiento micológico de las islas Baleares I. *Gasteromycetes*. *Bol. Soc. Micol. Madrid* 13:139-150.

CALONGE, F. D., TORRE, M. & LAWRYNOWICZ, M. (1977). Contribución al estudio de los hongos hipogeos de España. *Anales Inst. Bot. Cavanilles* 34:15-31.

CASTELLANO, M. A., TRAPPE, J. M. MASER, Z. & MASER, Ch. (1989). *Key to Spores of the Genera of Hypogeous Fungi of North Temperate Forest.* Mad River Press Inc. Eureka, California, 186 pp.

CASTRO, M. L. & FREIRE, L. (1982). *Terfezia berberiodora* y *T. oligosperma* encontradas en Galicia, nuevas para España. *Collect. Bot., Barcelona* 13:441-444.

CERUTI, A. (1960). *Elaphomycetales et Tuberales. In: BRESADOLA, J., Iconographia Mycologica, vol. 28, suppl. II*. Trento.

CODINA, J. & FONT-QUER, P. (1930). Introducció a l'estudi dels macromicets de Catalunya. *Cavanillesia* 3:100-189.

GIL, J. R. & DIE, P. (1989). *Guía de Setas de Extremadura (2)*. Ed. Fondo Natural. Madrid. 112 pp.

GROSS, G., RUNGE, A., WINTERHOFF, W. & KRIEGLSTEINER, G. J. (1980). Bauchplilze (*Gasteromycetes* s. l.) in der

Bundersrepublick und Westberlin. *Zeitschr. Mykol. Beih.* 2:1-220.

HAWKER, L. G. (1954). British hypogeous fungi. *Phil. Trans. Roy. Soc. London* 237:429-546.

HEIM, R., FONT-QUER, P. & CODINA, J. (1934). Fungi Iberici; Observations sur la Flore Mycologique Catalane. *Treb. Mus. Ci. Nat. Barcelona, Ser. Bot.* 15(3):1-146.

HONRUBIA, M., CANO, A. & MOLINA-NIÑIROLA, C. (1990). Nota sobre hongos hipogeos del semiárido murciano. Resúmenes V reunión Conjunta de Micología. *Rev. Iberoamericana Micol.* 7:95.

JEPPSON, M. (1987). Notes on some Spanish *Gasteromycetes. Bol. Soc. Micol. Madrid* 11:267-282.

LAZARO-IBIZA, B. (1912). Notas micológicas. Colección de datos referentes a los hongos de España. Tercera serie. *Mem. Real Soc. Esp. Hist. Nat.* 7:287-341.

LAZZARI, G. & MONTECCHI, A. (1985). *Tuber malençonii. Boll. Gruppo Mycol. G. Bresadola (Trento)* 28:80-81.

LOCQUIN, M. V. (1975). *Guide des couleurs naturelles.*

MAIRE, R. (1937). Fungi Catalanici. Series altera. Contributions à l'ètude de la Flore Mycologique de la Catalogne. *Publ. Inst. Bot. Barcelona* 3:3-128.

MALENÇON, G. & BERTAULT, R. (1971). Champignons de la Péninsule Ibérique. I. Explorations entre le Midi Valencien et le Montseny. *Acta Phytotax. Barcinon.* 8:1-68.

MENDAZA, R. & DIAZ, G. (1987). *Las Setas.* Ed. Iberduero, Vizcaya. 932 pp.

MILLER, S. L. (1989). A systematic evaluation of basidiospore symmetry and tegumentation in hypogeous and gasteroid *Russulales. Can. J. Bot.* 66:2561-2573.

MILLER, S. L. & MILLER, O. K. (1986). *Zelleromyces stephensii,* an interesting member of the gasteroid *Russulales* from Europe. *Mycol. Helvet.* 2:59-66.

MONTECCHI, A. & LAZZARI, G. (1984a). Invito allo studio dei funghi ipogei. *Boll. Gruppo Micol. G. Bresadola (Trento)* 27:100-116.

MONTECCHI, A. & LAZZARI, G. (1984b). Invito allo studio dei funghi ipogei II. Il genere *Tuber. Boll. Gruppo Micol. G. Bresadola (Trento)* 27:196-214.

MONTECCHI, A. & LAZZARI, G. (1987). Tartufi del gruppo *T. puberulum* nell'Appennino reggiano. *Mic. Ital.* 3:147-158.

MONTECCHI, A. & LAZZARI, G. (1988a). Contributo critico alla conoscenza dei tartufi della stirpe "rufum". *Boll. Gruppo Micol. G. Bresadola (Trento)* 31:320-330.

MONTECCHI, A. & LAZZARI, G. (1988b). Invito allo studio dei funghi ipogei IV. I Gasteromiceti. *Boll. Gruppo Micol. G. Bresadola (Trento)* 31:77-92.

MORENO, G., GALAN, R. & ORTEGA, A. (1986). Hypogeous Fungi from Continental Spain. I. *Cryptogamie, Mycol.* 7:201-229.

PEGLER, D. N. & YOUNG, T. W. K. (1979). The gasteroid *Russulales*. *Trans. Br. Mycol. Soc.* 72:353-388.

RIOUSSET, L. & RIOUSSET, G. (1990). *Tuber oligospermum* (Tul. & Tul.) J. M. Trappe comb. nov. 1979. Specie mal conosciuta. *Il Fungo* suppl. nº 4, nº spec. "II Seminario Inter. di ricerca estudio sui funghi ipogei":12-13.

SINGER, R. & SMITH A. H. (1960). Studies on secotiaceous fungi. IX. The astrogastraceous series. *Mem. Torrey Bot. Club* 21:1-112.

SINGER, R. (1947). Champignons de la Catalogne. Espèces observées en 1934. *Collect. Bot., Barcelona* 1:199-246.

SOBRADO-MAESTRO, C. (1911). Datos para la Flora micológica gallega. *Bol. Soc. Esp. Hist. Nat.* 11:474-476.

SOEHNER, E. (1962). Die Gattung *Hymenogaster* Vitt. *Beih. Nova Hedw.* 2:1-113.

SVRCEK, M. (1958). *Hysterangiales. In: A. Pilát (ed.), Flora C. S. R., Gastéromycètes. Praha, C. S. A. V.*: 96-120.

TULASNE, L. R. & TULASNE, C.(1851). *Fungi Hypogaei*. F. Klinscksieck, Paris. 222 pp.

WILDPRET, W., BELTRAN, E. & SANTOS, A. (1972). Adiciones al catálogo de *Gasteromycetes* de las Islas Canarias. *Vieraea* 2:103-109.

ZHANG, B. Ch. & YU, Y.-N. (1990). Two new species of gasteroid *Russulales* from China, with notes on taxonomy of *Gymnomyces*, *Martellia* and *Zelleromyces*. *Mycol Res.* 94:457-462.

MYCOTAXON

Volume XLII, pp. 239-243 October-December 1991

A NEW SPECIES OF PHIALOMYCES

Rafael F. Castañeda Ruiz[1] and W. Gams[2]

[1]Instituto de Investigaciones Fundamentales en Agricultura
Tropical "Alejandro de Humboldt", Ministerio
de la Agricultura, Santiago de las Vegas, Calle 1 Esq. 2,
Ciudad de la Habana, Cuba.

[2]Centraalbureau voor Schimmelcultures, P.O. Box 273,
3740 AG, Baarn, The Netherlands

Abstract: *Phialomyces striatus* sp. nov., found on decaying leaves of *Pachyanthus poirettii* Griseb., is characterized by long chains of longitudinally striate conidia. It is delimited against *Penicillium*, *Memnoniella* and *Sagenomella.*

Resumen: Se describe e ilustra una nueva especie, *Phialomyces striatus*, hallada sobre hojas caídas de *Pachyanthus poirettii* Griseb. La especie es caracterizada por largas cadenas de conidios estriados. La delimitación contra los géneros *Memnoniella, Penicillium* y *Sagenomella* es discutida.

Key words: *Phialomyces cubensis*, new species, *Penicillium, Memnoniella, Sagenomella.*

Phialomyces striatus Castañeda & W. Gams, sp. nov.

Coloniae effusae, velutinae, hypophyllae, olivaceae. Mycelium partim superficiale et partim in substrato immersum, ex hyphis septatis, ramosis, levibus, hyalinis, 2–2.5 µm diam, compositum. *Conidiophora* conspicua, erecta, recta vel flexuosa, cylindrica, simplicia vel ramosa, septata, levia, hyalina, 35–85 µm alta, ad basim 2.5–3.5 µm crassa. *Cellulae conidiogenae* monophialidicae, discretae, verticillatae, determinatae, raro percurrentes, anguste lageniformes, apicem versus attenuatae, leves, hyalinae, 11–15 × 2.5–4 µm. *Conidia* catenata, ellipsoidea, fusiformia, interdum citriformia, unicellularia, sicca, longitudine costata, primum hyalina, deinde fuscescentia, in massa olivacea, 7–11 × 2.5–3.5 µm, in cultura 7.5–13 × 3.5–5 µm.

Holotypus INIFAT C89/170, leg. R. F. Castañeda, 27 Mar. 1989, in foliis dejectis *Pachyanthi poirettii*, Viñales, Pinar del Río, in Cuba. Isotypus vivus et exsiccatus CBS 550.89.

Colonies on the natural substratum dispersed, hairy or slightly cottony, hypophyllous, olivaceous. Mycelium partially superficial and partially immersed in the substratum, consisting of septate, branched, smooth-walled, hyaline hyphae, 2–2.5 µm wide. *Conidiophores* conspicuous, erect, straight or flexuous, cylindrical, simple or branched, septate, smooth-walled, hyaline, 35–85 µm tall and 2.5–3.5 µm wide at the base. *Conidiogenous cells* monophialidic, discrete, determinate, rarely percurrently proliferating, slender lageniform, tapering into a cylindrical apical part, smooth-walled, hyaline, 11–15 × 2.5–4 µm. *Conidia* in chains, ellipsoidal, fusiform to citriform, rarely globose, one-celled, dry, with coarse longitudinal ribs, initially hyaline, later becoming pale olivaceous, in mass dark olivaceous, 7–11 × 2.5–3.5 µm, provided with connectives at both ends, the apical one longer.

Colonies on malt extract or cornmeal agars reaching 55 mm diam in 7 days at 27–30°C, initially whitish-grey, floccose and whitish grey in reverse, sporulation abundant in the centre, giving the colony a herbage green to dull green aspect (Rayner, 1970, No. 69-70). *Conidiophores* erect, rarely simple, commonly branched with verticillate phialides borne at various levels, apically and below, generally hyaline and occasionally pigmented, up to 200 × 2.5–4 µm. *Phialides* and *conidia* as above, but conidia generally larger, 7.5–13 × 3.5–5 µm. Chlamydospores absent. Teleomorph unknown.

Temperature optimum for growth 27–33°C, maximum near 37°C; abundant sporulation occurring up to 30°C.

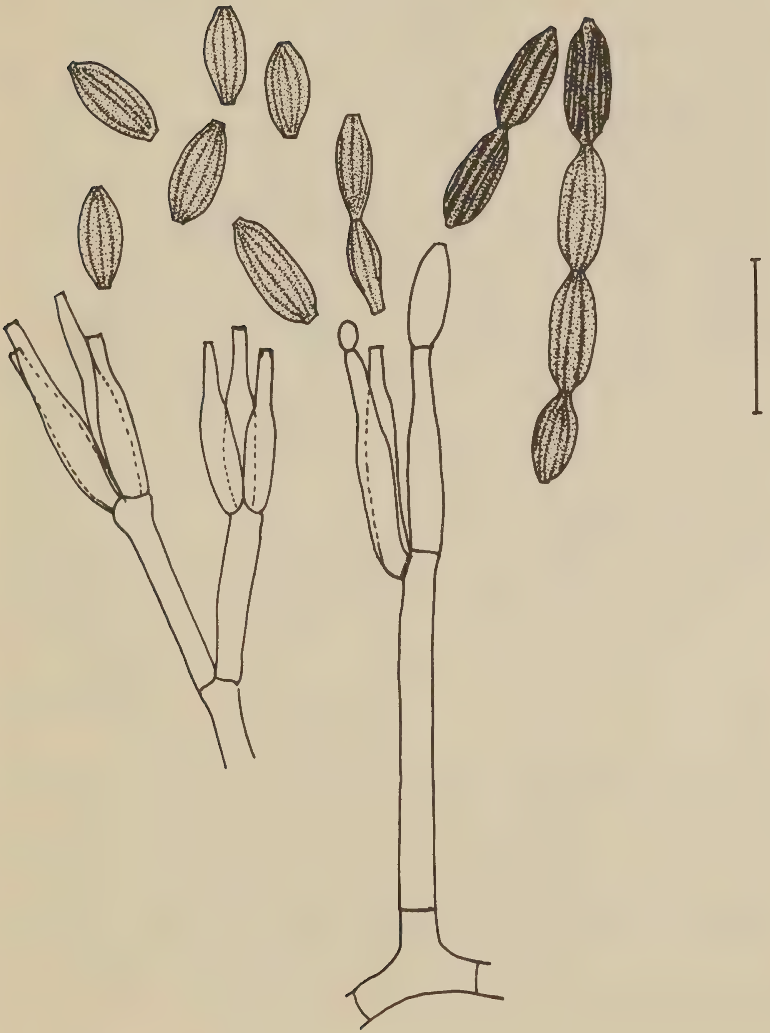


Fig. 1. *Phialomyces striatus*, CBS 55.89, from natural substrate.

Material: leaf litter of *Pachyanthus poirettii*, Viñales, Pinar del Río, Cuba, leg. R. F. Castañeda, 27 March 1989.

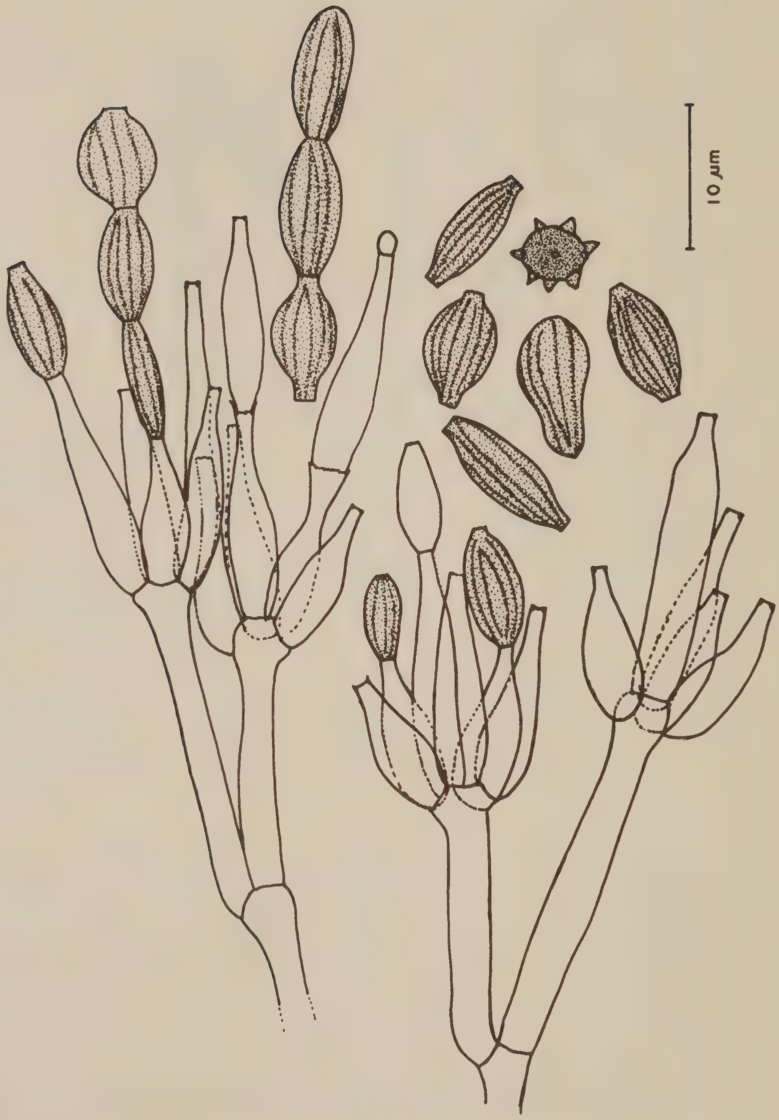


Fig. 2. *Phialomyces striatus*, CBS 55.89, from pure culture on malt extract agar.

The verticillate disposition of the phialides as well as the production of pigmented and ornamented catenate conidia allow to place the fungus in *Phialomyces* Misra & Talbot (1964). The type species, *Ph. macrosporus* has much larger (20–28 × 16–20 μm), thick-walled, coarsely warted and very darkly pigmented conidia, with very pronounced connectives, borne in rather short chains. *Ph. striatus* also seems to be related with *Penicillium*. The branching of the conidiophores would place it in subgenus *Furcatum*, but the conidial structures are unlike any known species in that genus. The present fungus seems to take an intermediate position between *Phialomyces* and *Penicillium*.

The fungus cannot be classified in *Memnoniella*, where the phialides are consistently densely crowded in a single apical whorl and the conidia are not provided with connectives. The conidia of *Ph. striatus* resemble those of *Sagenomella striatispora* (Onions & Barron) W. Gams (1978) in shape and ornamentation, but the fungus differs clearly in shape and disposition of the phialides, which in *Ph. striatus* are always verticillate in one or several levels as well as sometimes brown pigmented in the uppermost whorl. The growth rate differs clearly in both species: *S. striatispora* reaching 10 mm diam in ten days at 20°C, and *Ph. striatus* 32 mm at 20°C and 55 mm in 7 days at 27–30°C.

References

Gams, W., 1978. Connected and disconnected chains of phialoconidia and *Sagenomella* gen. nov. segregated from *Acremonium*. — Persoonia 10: 97–112.

Misra, P. C. & Talbot, P. H. B., 1964. *Phialomyces*, a new genus of the Hyphomycetes. — Can. J. Bot. 42: 1287–1290.

Rayner, R. W., 1970. A Mycological Colour Chart. — Commonwealth Mycological Institute, Kew, Surrey.

MYCOTAXON

Volume XLII, pp. 245-248 October-December 1991

NOMENCLATURAL REMARKS ON THE LICHENS HEPPIA SOLORINOIDES, PELTULA OBSCURANS AND P. PLACODIZANS

BURKHARD BÜDEL
Forschungsinstitut Senckenberg, Außenstelle Lochmühle, D-6465
Biebergemünd 3, Federal Republic of Germany

JOSÉ MARIA EGEA
Departamento de Biologia Vegetal (Botanica), Facultad de Biologia,
Universidad de Murcia, Spain

H. THORSTEN LUMBSCH
Botanisches Institut, Fb 9, Universität Essen, Postfach 103 764,
D-4300 Essen 1, Federal Republic of Germany

Abstract: The correct citation of one species of the lichen genus *Heppia* and two species of the genus *Peltula* is discussed. The three species are *Heppia solorinoides* (Nyl.) Nyl., *Peltula obscurans* (Nyl.) Gyelnik and *Peltula placodizans* (Zahlbr.) Wetmore.

Introduction

In the recent literature dealing with lichens of the genera *Heppia* and *Peltula* (e.g. EGEA 1989, FILSON 1988, SWINSCOW 1982), for three species, which are mentioned below, different epithets are used. The names *Heppia solorinoides* (Nyl.) Nyl. and *Heppia reticulata* (Duf.) Nyl. were applied for one and the same species (e.g. HUE 1907, GYELNIK 1935a, SWINSCOW 1982, EGEA 1989). More recently, the species *Peltula obscurans* (Nyl.) Gyelnik was placed into synonymy with *Peltula subglebosa* (Müll. Arg.) Filson and *Peltula placodizans* (Zahlbr.) Wetmore was synonymized with *Peltula decorticans* (Müll. Arg.) Filson (FILSON 1988). In this paper we briefly discuss the correct names for these three species.

The Species

Heppia solorinoides (Nyl.) Nyl.; Syn. Meth. Lich. 2: 46 (1863). – *Lecanora solorinoides* Nyl., Ann. Sci. Nat. Bot., ser. 3, 20: 323 (1853); type: Syria, Beiruth, Blanche (H-NYL p.m. 2484, Holotype; not seen).

Heppia reticulata Nyl., Flora 61: 339 (1878). - *Endocarpon reticulatum* Dufour in Fries, Lich. Eur. Ref.: 410 (1831), nom. illeg. (non Steudel, Nomencl. Bot.: 161 1824); type: Spain, rock fissures, Dufour (H-NYL 30912, probably isotype).

Endocarpon reticulatum Dufour in Fr. antedates *Endocarpon reticulatum* Steudel (1824) and is therefore illegitimate according to the Code (Art. 64.1) (GREUTER et al. 1988). NYLANDER (1878) placed *Endocarpon reticulatum* Dufour in Fr. into the genus *Heppia* and, in doing so, effectively published the name. According to Art. 72 of the Code, the combination has to be treated as a nomen novum which implies that the species is now correctly named *Heppia reticulata* Nyl. Further studies revealed (e.g. SWINSCOW 1982), that *Heppia solorinoides* (Nyl.) Nyl. is conspecific with *Heppia reticulata* (Nyl.) Nyl. Since *Lecanora solorinoides* Nyl. was published three years earlier than *L. reticulata* Nyl., the former epithet has priority.

Peltula obscurans (Nyl.) Gyelnik; Repert. Spec. Nov. Regni Veg. 38: 308 (1935). - *Endocarpiscum obscurans* Nyl., Bull. Soc. Linn. Normandie II. 6: 309 (1872), type: France, Colliure, Nylander 1872 (H-NYL 30900, lectotype selected by WETMORE 1971). – *Heppia obscurans* (Nyl.) Nyl., in Hue, Rev. Bot. Bull. Mens. 5: 18 (1886).

Acarospora collemacea Wedd., Bull. Soc. Bot. France 21: 343 (1874), type: France, Agde, Weddel (not seen);

Endocarpiscum aterrimum Stirt., J. Linn. Soc. Bot. 14: 366 (1874); – Heppia meiolepis Cromb., nom. nov., J. Linn. Soc. Bot. 16: 212 (1877); type: Cape Verde, Sao Vicente. Challenger Exped. 1873 (Holotype BM).

Heppia acarosporoides Müll. Arg., Hedwigia 31: 194 (1892), type: Ad terram in Western Australia, Camp 1: H. sine no (Holotype G, not seen);

Heppia deserticola Zahlbr., Bull. Torrey Bot. Club 35: 300 (1908), type: southward facing tuff, Tucson, Arizona, Station III, March 1908. J.C. Blumer. (Isotype MICH);

Heppia deserticola f. *minor* Zahlbr., Ann. Mycol. 7: 474 (1909), type: Arizona, Tucson, on rocks, Blumer, 1908 (Isotypes MICH, MU);

Heppia hassei Zahlbr., Beih. bot. Zbl. 13: 157 (1902), type: California, Palm Springs, ad saxa granitica, Hasse FN 817 (Lectotype W);

Heppia michoacanensis var. *adnata* B.de Lesd., Lich. Mexique, 1. Suppl.: 8 (1922), type: Mexico, Michoacán, Azotea de San Borja, Arsène 9604, 1914 (Lectotype US, not seen);

Heppia murorum Vain., Acta Soc. Fauna Fl. Fenn. 7(1): 218 (1890), type: Brasil, Rio de Janeiro, ad cementum muri, Vainio, Lich. Brasil Exs. 190 (Isotype FH);

Placodium subglebosum Müll. Arg., Flora 72: 510 (1889), type: Riv. Negro, Sud Argentimin: Dr. Lorentz 1882. Saxicola ad Rio Negro (Lectotype G).

The type material of *Endocarpiscum obscurans* consists of two specimens numbered as 30900 and 30897 without indication of a holotype. A careful description of the species is given by HUE (1907), who did not select a lectotype. When GYELNIK (1935b) studied the type material of *P. obscurans*, he selected the specimen H-NYL 30897 as the lectotype of *P. obscurans*, but mentioned, that the specimen was very small and resembled *P. euploca*.

In WETMORE's treatment (1971) of the North American Heppiaceae, he found the lectotype (H-NYL 30897) selected by GYELNIK includes only *P. euploca*, but the specimen H-NYL 30900 agreed well with the original description. In correspondence with Art. 8 (8.1-b) of the Code (GREUTER et al. 1988), WETMORE (1971) selected the specimen

H-NYL 30900 for the lectotype of *P. obscurans*, which was accepted by most later authors.

However, FILSON (1988) did not follow this opinion and argued that GYELNIK's (1935b) lectotypification was correct and found the lectotype of *P. obscurans* to be identical with *P. euploca*. Consequently, FILSON (1988) placed *P. obscurans* into synonymy with *P. euploca*. The available epithet for the lichen described as *P. obscurans* was then *Peltula subglebosa* (Müll.Arg.) Filson.

Art. 7 (recommendation 7B.3) of the Code recommends a lectotypification which closely follows the protologue. Obviously, the protologue was not followed by GYELNIK's decision. Therefore we propose to follow WETMORE (1971) and to refuse GYELNIK's lectotypification which was based on a misinterpretation of the protologue!

Peltula placodizans (Zahlbr.) Wetmore. Ann. Missouri Bot. Gard. 57: 196 (1971). - *Heppia placodizans* Zahlbr., Bull. Torrey Bot. Cl. 35: 299 (1908); type: U.S.A., Arizona, Tucson, Tumamoc Hill, station II, southward facing cliff of boulders, 2600 ft., Blumer, 1908 (Holotype W; Isotypes DS, FH, Mich).

FILSON (1988) regarded the name *Pyrenopsidium decorticans* Müll. Arg. as belonging to a species of *Peltula* and consequently made the combination *Peltula decorticans* (Müll. Arg.) Filson. *Peltula placodizans* was thought to be identical with *Peltula decorticans* and because of the priority of the latter epithet, placed *P. placodizans* into synonymy with *P. decorticans*. However, *Pyrenopsidium decorticans* was originally described by J. MÜLLER (1892) as a lichen with polysporous asci and unicellular blue-green algal photobionts, having red sheath. In addition, he compared it with another *Pyrenopsis*-species. This description does not fit well for a species of *Peltula*. Therefore we studied the isotype material of *Pyrenopsidium decorticans* (MEL) and we found the red *Pyrenopsidium decorticans* thalli well in correspondence with the protologue. *Pyrenopsidium decorticans* thalli were intermixed with several thalli of *Peltula placodizans*. The holotype material (G) of *Pyrenopsidium decorticans* however, had no thalli of *Peltula placodizans*.

We consider the selection of the *Peltula*-part of the isotype material of *Pyrenopsidium decorticans* by FILSON, as a misunderstanding of the protologue. According to our studies, *Pyrenopsidium decorticans* belongs to the family Lichinaceae and is clearly separated from *Peltula placodizans* by thallus morphology, ascus structure and the type of photobiont. *Peltula placodizans* is therefore the correct name for a species within the "critical group" (BÜDEL 1987), which is characterized by olive to brown, peltate to lingulate thalli with up to 1.3 mm high and 0.5 mm tall squamules and small punctiform apothecia.

References

BÜDEL, B. 1987. Zur Biologie und Systematik der Flechtengattungen *Heppia* und *Peltula* im südlichen Afrika. *Bibliotheca Lichenologica* 23: 1-150.

EGEA, J.M. 1989. Los géneros *Heppia* y *Peltula* (Lìquenes) en Europa Occidental y Norte de Africa. *Bibliotheca Lichenologica* 31: 1-122.

FILSON, R.B. 1988. The lichen genera *Heppia* and *Peltula* in Australia. *Muelleria* 6: 495-517.

GREUTER, W., BURDET, H.M., CHALONER, W.G., DEMOULIN, V., GROLLE, R., HAWKSWORTH, D.L., NICOLSON, D.H., SILVA, P.C., STAFLEU, F.A., VOSS, E.G. and MCNEIL, J. 1988. International Code of Botanical

Nomenclature. Adopted by the fourteenth international botanical congress, Berlin, July-August 1987. Koeltz Scientific Books, Königstein, Germany. pp. 328.

GYELNIK, V.K. 1935a. De familia Heppiacearum I. *Fedde Repertorium* 38: 153-157.

GYELNIK, V.K. 1935b. De familia Heppiacearum II. *Fedde Repertorium* 38: 307-313.

HUE, A. 1907. Heppiearum ultimae e familiae collemacearum tribubus nonnulas species morphologice et anatomice elaboravit. *Memoir Soc. Nation. Scienc. Natur. Cherbourg*, 36: 1-44.

MÜLLER, J. 1892. Lichenes australiae occidentalis. *Hedwigia* 31: 191-198.

NYLANDER, W. 1878. Symbolae quaedam ad Lichenographiam Sahariensem. *Flora* 61: 337-345.

SWINSCOW, T.D.V. 1982. The genera *Heppia* and *Peltula* in Tenerife. *Lichenologist* 14: 76-83.

WETMORE C.M. 1971. The lichen family Heppiaceae in North America. *Ann. Missouri Bot. Gard.* 57: 158-209.

MYCOTAXON

Volume XLII, pp. 249-254 October-December 1991

ANAMYLOPSORA, A NEW GENUS IN THE LECIDEACEAE

EINAR TIMDAL

Botanical Museum
University of Oslo
Trondheimsveien 23 B, N-0562 Oslo 5, Norway

SUMMARY

The new, monotypic genus *Anamylopsora* Timdal is described and the new combination *A. pulcherrima* (Vainio) Timdal is proposed. The genus differs from *Psora* Hoffm. mainly in having a non-amyloid tholus and hymenial gelatine, in lacking anthraquinones in the hymenium, and in having a different type of upper cortex and pycnidium. *Lecidea undulata* Magnusson is reduced to synonymy with *A. pulcherrima*. The species, which was previously known from arid areas of Asia, is reported as new to North America (Alaska).

INTRODUCTION

In a previous paper on the delimitation of *Psora* Hoffm. (Timdal 1984), the saxicolous, squamulose lichen *Psora pulcherrima* (Vainio) Elenkin (syn. *Lecidea pulcherrima* Vainio) was excluded from the genus. There was apparently no genus to accommodate the species, and it was temporarily left in the collective genus *Lecidea* Ach. Several recent studies of the Lecideaceae have demonstrated the taxonomic importance of the amyloid reaction in the ascus apex, and convinced me of the necessity of introducing a new genus for this species.

MATERIAL AND METHODS

The material consists partly of previously published material of the species and partly of specimens found, often accidentally, in the herbaria during my studies on *Psora*.

Microscope sections cut on a freezing microtome were placed in H_2O, lactophenol cotton blue, chlor-zinc-iodine (ClZnI), and a modified Lugol's solution in which H_2O was replaced by lactic acid. Amyloid reactions were observed in the modified Lugol's solution following pretreatment with 10% KOH. Polarized light was used to locate crystals and granules in the sections. Calcium oxalate was identified under the microscope by adding 25% H_2SO_4 to an aqueous mount, causing the crystals to dissolve and recrystallize by forming needle-shaped crystals of calcium sulphate. All specimens, including the type material, were subjected to thin-layer chromatography, performed in accordance with standard methods (Culberson 1972).

TAXONOMY

Anamylopsora Timdal, gen. nov.

Thallus squamosus. Cortex superioris ad typum "Kegelrinden" pertinet. Stratum algaceum interruptum; algae virides, unicellulares. Apothecia lecideina, badioatra vel atra, ad marginem squamarum affixa. Excipulum annulare. Hypothecium pallidum. Hymenium non amyloideum, sine crystalliis. Asci subcylindrici vel cylindrico-clavati, tholo non amyloideo. Sporae octonae, incolores, simplices, subglobosae. Pycnidia mox sessilia, ad marginem squamarum affixa.

Typus generis: *Anamylopsora pulcherrima* (Vainio) Timdal.

Thallus squamulose. Upper cortex of "Kegelrindentyp" (in the terminology of Poelt 1958). Photobiont layer discontinuous; photobiont green, unicellular algae. Medulla non-amyloid.

Apothecia lecideine, attached to the margin of the squamules. Excipulum annular. Hypothecium pale brown to colourless, filled with crystals of calcium oxalate. Hymenium lacking crystals, granules, and oil droplets; hymenial gelatine non-amyloid. Epithecium brown, K–. Paraphyses simple or sparingly branched and anastomosing, rather weakly conglutinated; apical cell slightly thickened and brown pigmented. Ascus narrowly clavate to subcylindrical, surrounded by an amyloid sheet; tholus more or less well developed, without an ocular chamber, non-amyloid. Spores simple, colourless, non-halonate, 8 in the ascus, broadly ellipsoid to subglobose.

Pycnidia soon becoming sessile at the margin of the squamules, dark brown to black. Conidiophores forming a paraplectenchymateous tissue. Pycnoconidia narrowly ellipsoid to short bacilliform.

Anamylopsora pulcherrima (Vainio) Timdal, comb. nov.

Lecidea pulcherrima Vainio, Acta Horti Petropolit. 10: 561 (1889). – *Psora pulcherrima* (Vainio) Elenkin, Acta Horti Petropolit. 24: 105 (1904). – Type: U.S.S.R., Turkmenskaya S.S.R., "Kopet-Dagh über Aschk'bad", 27 July 1886, G. Radde (TUR–VAINIO 22644, holotype).

Lecidea hedinii Magnusson, Lich. Central Asia: 56 (1940) – Type: China, Gansu, "Ehr-tao-ch'uan (Nan-Shan)", alt. c. 3000 m, 2 January 1932, B. Bohlin 72 (S, holotype).

Lecidea undulata Magnusson, Lich. Central Asia: 60 (1940). – Type: China, Gansu, "Yü-ehr-hung", alt. 2700–2800 m, 5 February 1932, B. Bohlin 82 (S, holotype).

Psora pulcherrima var. *elegantula* Elenkin, Acta Horti Petropolit. 24: 105 (1904). – Type: Mongolia, Hövsgöl, "in ripis flum. Norin-Chore prope lac. Kossogol in Mongolia boreali", 1902, A.A. Elenkin (Elenkin, Lich. Fl. Ross. No 192a; UPS, syntype) [No 192b not seen].

Thallus squamulose, up to 10 cm diam., saxicolous. Squamules up to 2 (–3) mm diam., varying from mainly ascending and more or less imbricate to forming an areolate crust in the central part of the thallus and radiating lobes along the margin. Upper side ochraceous brown, dull or somewhat shiny, epruinose or more rarely pruinose. Margin entire, crenulate, or lobate, more or less white pruinose. Underside pale brown to white near the margin, dark brown to black in the central part. Upper cortex consisting of (1) an upper epinecral layer, 5–10 µm thick; (2) a central, pigmented layer, 35–180 µm thick, containing pale brown granules dissolving in K, K+ faintly yellow, PD+ distinctly yellow (alectorialic acid), composed of apparently randomly oriented, short-celled, rather thick-walled hyphae; and (3) a lower colourless layer, 40–150 µm thick, lacking crystals and granules, K−, PD−, composed of more anticlinally oriented, more thin-walled hyphae and containing remnants of dead algae in more or less conical areas; each cone of dead algae is situated just above a group of algae in the photobiont layer (ClZnI; conforms with the "Kegelrindentyp" of Poelt 1958). Photobiont layer discontinuous, 120–220 µm thick; photobiont green, unicellular algae. Medulla non-amyloid, containing crystals of calcium oxalate. Lower cortex 5–20 µm thick, brown, K−, lacking crystals and granules.

Apothecia lecideine, up to 1 (−1.3) mm diam., simple or forming conglomerates up to 6 mm diam., attached to the margin of the squamules, more or less plane and indistinctly marginate when young, soon becoming strongly convex and immarginate, dark brown to black, dull, epruinose. Excipulum annular, composed of radiating hyphae, lacking crystals and granules, inner part colourless, rim brown, K−. Hypothecium continuous with medulla, pale brown in upper part, colourless below, filled with crystals of calcium oxalate. Hymenium 60–100 µm high, lacking crystals, granules, and oil droplets; hymenial gelatine non-amyloid. Epithecium brown, K−. Paraphyses rather weakly conglutinated, simple or sparingly branched and anastomosing; apical cell slightly thickened and brown pigmented. Asci narrowly clavate to subcylindrical, surrounded by an amyloid sheet; tholus more or less well developed, without an ocular chamber, non-amyloid. Spores simple, broadly ellipsoid to subglobose, colourless, non-halonate, 7–11 × 6–10 µm.

Pycnidium immersed in the medulla when young, soon becoming sessile at the margin of the squamules, globose, up to 0.3 mm diam., dark brown to black. Conidiophores forming a paraplectenchymateous tissue, resembling type VII or VIII of Vobis (1980). Pycnoconidia narrowly ellipsoid to shortly bacilliform, about 3 × 1 µm.

Chemistry: Alectorialic acid (in the upper cortex).

Illustrations: Magnusson (1940: Plate 11, Fig. 4, habit), Magnusson (1942: Plate 6, Fig. 1, habit), Hertel (1977: Fig. 48, habit), Schneider (1980: Fig. 73, habit), Timdal (1984: Fig. 1D, transverse section through thallus and pycnidium; Figs 5C, 6C, ascus).

Exsiccata: Elenkin, Lich. Fl. Ross. No 192a (UPS) [No 192b not seen].

Affinities: *Anamylopsora* differs from *Psora* mainly in having a different type of ascus, a non-amyloid hymenial gelatine, in lacking anthraquinones in the hymenium, in having a discontinuous algal layer, and in having different types of upper cortex and pycnidium. In *Psora* the ascus has a well developed amyloid tholus which contains a deeper amyloid tube, the hymenial gelatine is amyloid, anthraquinones are present in the upper part of the hymenium, the algal layer is continuous, the upper cortex is of the "Scheinrindentyp" (in the terminology of Poelt 1958), and the pycnidium persistently immersed in the squamules (Timdal 1984). The genera are morphologically quite similar, but *Anamylopsora* may be distinguished by the presence of dark brown to black, sessile, marginal pycnidia.

In the system of families segregated from the Lecideaceae by Hafellner (1984), and most recently modified by Eriksson & Hawksworth (1991), *Anamylopsora* should apparently be placed in the Trapeliaceae. In this system, the families are characterized mainly by minute details in the amyloid reaction in the tholus. The genera of the Trapeliaceae have subcylindrical asci with a non-amyloid tholus or a tholus with merely a faintly amyloid lateral ring or a weakly amyloid apical cap (Lamb 1947, Hertel 1970, Schneider 1980, Coppins & James 1984, Hafellner 1984, Scheidegger 1985). As far as presently known, *Anamylopsora* differs from the genera of the Trapeliaceae, however, in having an upper cortex of the "Kegelrindentyp", a non-amyloid hymenial gelatine (except from *Anzina*), less reticulately branched paraphyses, sessile pycnidia, and in the presence of calcium oxalate in the hypothecium. Alectorialic acid is not known from the Trapeliaceae; the species of this family produce mainly gyrophoric acid, lecanoric acid, fumarprotocetraric acid, salazinic acid, the unknown compound of *Trapeliopsis*, or no lichen substances (cfr the authors cited above). It appears to me that the similarity in ascus type between *Anamylopsora* and the genera of the Trapeliaceae could be explained just as plausibly by convergence as by common origin.

Among the squamulose species of the Lecideaceae s.lat., a similar type of pycnidium occurs in *Lecidea lurida* Ach. and *Psorula rufonigra* (Tuck.) G. Schneider. These species differ from *Anamylopsora* in the type of ascus (being more or less similar to that of *Psora*), in having an amyloid hymenial gelatine, lacking calcium oxalate in the hypothecium, and in having a continuous algal layer (Timdal 1984).

Luxuriant forms of *Tephromela armeniaca* (DC.) Hertel & Rambold may resemble *A. pulcherrima* morphologically. This species also usually produce alectorialic acid in the thallus, but may be distinguished by having an amyloid hymenial gelatine and an amyloid tholus containing a deeper amyloid tube.

Schneider (1980) placed *A. pulcherrima* in *Psora*, *L. hedinii* in *Lecidea* s. lat., and synonymized *L. undulata* with *Psora concava* B. de Lesd. *Lecidea hedinii* was placed in synonymy with *A. pulcherrima* by Timdal (1984), and *L. undulata* is synonymized with this species here. *Psora concava* belongs in *Psora*, and is a synonym of *P. crenata* (Taylor) Reinke (Timdal 1987).

Ecology and distribution: *Anamylopsora pulcherrima* is a saxicolous species, growing both on calciferous and non-calciferous rocks. It has a wide distribution in the arid areas of the Northern Hemisphere, occurring in U.S.S.R., Mongolia, China, Nepal, and U.S.A. (Fig. 1). Hertel (1977) summarized the previously published localities for the species; three of these localities (including one from the Azerbaydzhanskaya S.S.R., SE Europe) have not been verified by me and are not included in Fig. 1. The species is here reported as new to North America, where it is known from four collections from Alaska. The altitude was indicate on the label in four specimens from Asia, ranging from 2300 m to 3800–3900 m alt, and in two specimens from Alaska, at 1800 ft (=550 m) and 1970 ft (=600 m) alt.

Additional specimens examined: *U.S.S.R.*, Rossiyskaya S.F.S.R., Chitinskaya Oblast, "prope pag. Atamanovka, ad saxa ad flum. Nikischicha", 18 September 1927, A. Oxner (UPS). – *Mongolia*, Arhangay, "bei Zezerleg", 27 June 1978, S. Huneck MVR-49 (GZU); – Arhangay, "Zezerleg-Gebirge", 25 June 1983, S. Huneck MVR 83-135 (GZU); – Arhangay, "Tschulut-Gol", alt. 2300 m, 1 July 1983, S. Huneck MVR 83-134 (GZU); – Hovd, "Chovd Sum, Ongozny

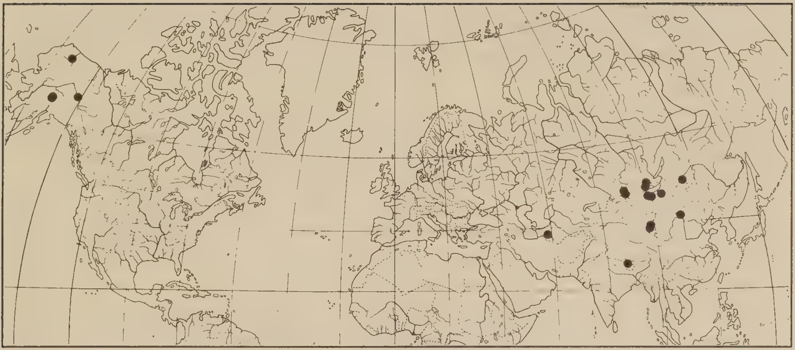


Fig. 1. *Anamylopsora pulcherrima*, world distribution.

Ulaan nul, Ongozny bulan", 11 June 1974, W. Hilbig & Z. Schamsran Hi-22 (GZU); – Hovd, "Nanchan Sum, Nordrand des Mongol-Altai", 15 June 1974, W. Hilbig & Z. Schamsran Hi-11 (GZU); – Hövsgöl, "Tomin-Brigade", 17 July 1983, S. Huneck MVR 83-210 (GZU); – Hövsgöl, "N-Hang des Sumber-Kul", 19 July 1983, S. Huneck MVR 83-203 (GZU); – Töv, "10 km W von Lun", 24 June 1983, S. Huneck MVR 83-186 (GZU). – *China*, Nei Mongol Zizhiqu, "Beli-miao", 41°30'N, 110°10'E, 25 October 1929, B. Bohlin 119 & 121 (S). – *Nepal*, "Langtang Area, slopes N of Kyangjin, moraines of Langtang Lirung Glacier", alt. 3800–3900 m, 9 September 1986, J. Poelt N86-L801 (GZU). – *U.S.A.*, Alaska, "Mt McKinley Nat. Park, hill E of road at Kantishna border of park", 63°30'N, 150°52'W, alt. 1970 ft, 17 July 1951, H. Croasdale 32A (COLO); – Alaska, "Mt McKinley Nat. Park, NW shore of Wonder Lake", 63°28'N, 150°55'W, alt. 1800 ft, 29 July 1956, W.A. Weber & L.A. Viereck S7230 (COLO); – Alaska, "along the north ridge of the Colville River, at Umiat", 69°25'N, 152°10'W, 24 July 1958, J.W. Thomson & S. Shushan 10298 (MIN, NEB, UAC, US); – Alaska, "about 1 mi W of Eagle on SW-facing 40° slope of Eagle Bluffs", 64°47'30"N, 141°12'40"W, 12 June 1979, L.P. Gough 1062 (WIS).

Acknowledgements: I wish to thank the curators of COLO, GZU, MIN, NEB, S, TUR, UAC, UPS, US, and WIS for the loan of specimens.

REFERENCES

Coppins, B.J. & James, P.W. 1984. New or interesting British lichens V. – Lichenologist 16: 241–264.

Culberson, C.F. 1972. Improved conditions and new data for the identification of lichen products by a standardized thin-layer chromatographic method. – J. Chromat. 72: 113–125.

Eriksson, E. & Hawksworth, D.L. 1991. Outline of the ascomycetes – 1990. – Systema Ascomycetum 9: 39–271.

Hafellner, J. 1984. Studien in Richtung einer natürlicheren Gliederung der Sammelfamilien Lecanoraceae und Lecideaceae. – Nova Hedwigia Beiheft 79: 241–371.

Hertel, H. 1970. Trapeliaceae – eine neue Flechtengattung. – Deutsch. Bot. Ges., Neue Folge 4: 171–185.

Hertel, H. 1977. Gesteinsbewohnende Arten der Sammelgattung *Lecidea* (Lichenes) aus Zentral-, Ost-, und Südasien. – Khumbu Himal 6, 3: 145–378.

Lamb, I.M. 1947. A monograph of the lichen genus *Placopsis* Nyl. – Lilloa 13: 151–288.

Magnusson, A.H. 1940. Lichens from Central Asia. Reports from the Scientific Expedition to the North-West Provinces of China under the Leadership of Dr. Sven Hedin. The Sino-Swedish Expedition. Publ. 13, XI. Botany 1. – Stockholm.

Magnusson, A.H. 1942. Lichens from Central Asia, Part II. Reports from the Scientific Expedition to the North-West Provinces of China under the Leadership of Dr. Sven Hedin. The Sino-Swedish Expedition. Publ. 22, XI. Botany 2. – Stockholm.

Poelt, J. 1958. Die lobaten Arten der Flechtengattung *Lecanora* Ach. sensu ampl. in der Holarktis. – Mitt. bot. StSamml. München 2: 411–589.

Scheidegger, C. 1985. Systematische Studien zur Krustenflechte *Anzina carneonivea* (Trapeliaceae, Lecanorales). – Nova Hedwigia 41: 191–218.

Schneider, G. 1980 ("1979"). Die Flechtengattung *Psora* sensu Zahlbruckner. – Biblioth. lichenol. 13: 1–291.

Timdal, E. 1984. The delimitation of *Psora* (Lecideaceae) and related genera, with notes on some species. – Nord. J. Bot. 4: 525–540.

Timdal, E. 1987 ("1986"). A revision of *Psora* (Lecideaceae) in North America. – Bryologist 89: 253–275.

Vobis, V. 1980. Bau und Entwicklung der Flechten-Pycnidien und ihrer Conidien. – Biblioth. lichenol. 14: 1–141.

MYCOTAXON

Volume XLII, pp. 255-262 October-December 1991

AN INDIGENOUS SPECIES OF LECCINUM (BOLETACEAE) FROM AUSTRALIA

N. L. BOUGHER * and H. D. THIERS **

* *CSIRO Division of Forestry Research, Private Bag,*
P.O. Wembley 6014, Western Australia.
** *Department of Biology, San Fransisco State University,*
1600 Holloway, CA 94132, U.S.A.

ABSTRACT

Leccinum australiense Bougher & Thiers is described as the first record of the genus associated with native vegetation in Australia. The species belongs in the section *Leccinum*, with its closest relative as perhaps *Leccinum intusrubens* (Corner) Hongo which differs in pigmentation and several other significant features. A mycorrhizal association between *L. australiensis* and *Eucalyptus grandis* Hill ex Maid. is postulated.

INTRODUCTION

The genus *Leccinum* S. F. Gray appears to be largely confined to the Northern Hemisphere. In North America, where it is far more abundant and diverse than elsewhere, it forms mycorrhizal associations most commonly with members of the Betulaceae and Pinaceae, but it is also known to associate with some members of the Fagaceae and Ericaceae (Singer, 1986). *Leccinum* has been considered rare in the Southern Hemisphere. Pegler (1977) for example, reported only one endemic species in a survey of East Africa. However, a few *Leccinum* species from mixed fagaceous forests in the Far East and tropical South-East Asia are now known, and they are associated with genera such as *Fagus*, *Quercus*, and *Castanopsis*. Prominent examples include: *L. extremiorientale* (L. Vass.) Sing. from Siberia, Korea and Japan (Hongo and Yokoyama, 1976); *L. nigrescens* (Rich. & Roze) Sing. from China and Japan (Hongo and Nagasawa, 1977); *L. intusrubens* (Corner) Hongo from Malaysia and Japan (Corner, 1972; Hongo, 1983); *L. subglabripes* (Peck) Sing. from Japan (Hongo, 1960) and the New Guinea highlands (Hongo, 1973).

Leccinum is characterised by the formation of moderate-size to robust basidiomes, a trichodermial pileipellis, white to pallid (rarely yellow) tubes, brown basidiospores and, most characteristically, the development of small, often abundant squamulae on the stipe surface. These squamulae are usually white at first but typically become very dark to near black with age. *Leccinum australiense*, described below, is significant as the first species of the genus known to be indigenous to Australia, and because it may enter into mycorrhizal association with *Eucalyptus*. All five species of *Leccinum* previously noted for Australia (some based on doubtful records) are undoubtedly introduced into Australia, as they are associated with horticultural plantings of *Betula* and *Quercus* (Watling and Gregory, 1988).

DESCRIPTION OF THE SPECIES

Leccinum australiense Bougher & Thiers, sp. nov. (Figs. 1 - 6)

Pileus *20-50 mm latus, convexus deinde late convexus, rufo-brunneus, immutabilis, siccus, glaber vel subtiliter velutinus, ad marginem extensus.* ***Tubuli*** *cremoricolores, immutabiles; pori parvuli, concolores.* ***Stipes*** *50-65 mm longus, 7-15 mm crassus, appresso-squamulosus, subalbidus; squamae pileo concolores velcyaneo-rufae, immutabiles; contextus*

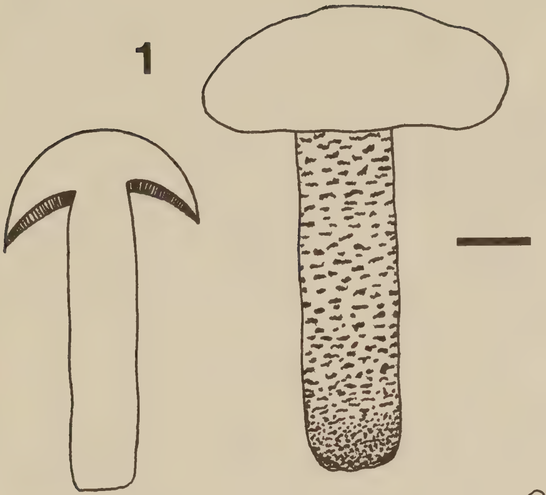
subalbidus, ubi expositus subgriseus. **Sporae** *fuscae in cumulo (12) 12.5-15 x 3.5-4.5 µm, subfusiformes, inaequilaterae.* **Pleurocystidia** *32-50 x 4-7 µm, basi inflata, ad apicem elongata, hyalina in KOH.* **Cheilocystidia** *20-48 x 4-10µm, filiformia vel strangulata, flavo-brunnea in KOH, deinde hyalina.* **Pileipellis** *intertexta, aetate irregularis, pigmentum areo-brunneum in KOH et Melzers praebens.*
In silvis Eucalyptus grandis. **Holotypus** (BRIP 17542) *a* N. Bougher *et* N. Malajczuk *lectus, prope Koombooloomba*, northern Queensland, Australia, 4 May 1988*; in* BRIP *conservatus.*

Pileus 20-50 mm broad; convex with decurved margin expanding to broadly convex with plane margin, margin smooth, entire and often extending beyond the perimeter of the hymenophore; reddish brown near 8-F/8 (Kornerup and Wanscher, 1978) unchanging with age; dry, smooth or finely velutinous during all stages of development. Context pale grey with darker grey inclusions. **Tubes** ± 5mm long at maturity; adnate at first then adnexed at maturity; cream unchanging with age, bruising pale grey when exposed to air. **Pores** very small (less than 0.5 mm); circular, of uniform size; concolorous with pileus, not bruising. **Stipe** 50-65 mm long x 7-15 mm broad; central, cylindrical, solid; appressed-squamulose, ground colour whitish, scales concolorous with pileus or with slight ruby (bluish red) tinge, unchanging with age, forming a nearly unbroken covering when young then later only near the stipe base. Context white then soon pale grey with darker grey inclusions. **Mycelium** at base of stipe white, forming a sclerotioid mass with soil. **Odour** of green vegetable. **Taste** not distinctive.
Macrochemical tests 15% KOH pale green on pileus context.
Spore print dark brown, without olive tinges.

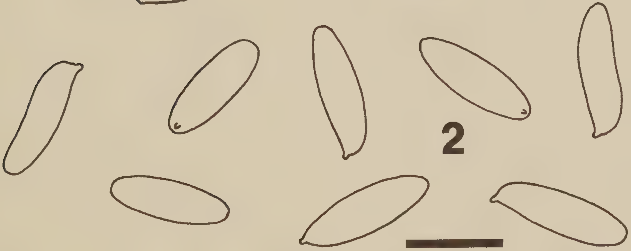
Basidiospores (12) 12.5-15 x 3.5-4.5 µm, mean length of 60 spores in KOH 12.93 µm, mean breadth of 30 spores in side view 4.03 µm (mean L/B ratio 3.21), mean breadth of

30 spores in face view 4.22 µm (mean L/B ratio 3.06); subfusiform in face view, inequilateral in side view, wall about 0.5 µm thick, smooth, hilar appendix small (less than 0.5 µm long), hyaline; pale yellow in KOH, golden yellow in Melzer's reagent. **Basidia** 20-30 x 7-10 µm; clavate, narrowest at base, thin-walled, hyaline in KOH, quadrisporic, sterigmata up to 4 µm long. **Pleurocystidia** 32-50 x 4-7 µm; swollen base and long narrow neck (usually 2-4µm broad) with obtuse apex extending well beyond hymenium, thin-walled, hyaline in KOH, abundant in parts. **Cheilocystidia** 20-48 x 4-10µm, necks usually 3-5 µm broad and bases up to 10µm broad; filiform to strangulated - some with swollen base, thin-walled, soon hyaline in KOH after bright yellow-brown cytoplasmic pigment dissolves, scattered basidia intermixed. **Tube trama** divergent, mediostratum of thin-walled hyphae (3-5 µm broad) with honey-brown cytoplasmic pigment, lateral strata of thin-walled, hyaline hyphae (5-7 µm broad). **Pileipellis** a palisade trichoderm at first then disorganising with age, terminal cells 7-15 x 4-12 µm, undifferentiated or slightly swollen (clavate, sphaeropedunculate or napiform), with golden brown cytoplasmic pigment (in KOH and in Melzer's reagent). **Scales on stipe** composed of erect hyphae with clavate, vesiculose or long-necked terminal cells. Golden yellow (in KOH) cytoplasmic pigment present, and scattered basidia producing short spores (5.5-7 x 3-4.5 µm). **Pileus trama** interwoven, hyaline hyphae (4-8 µm broad), occasional oeliferous hyphae. **Stipe trama** longitudinal hyaline hyphae (5-7 µm broad), occasional oeliferous hyphae. **Clamp connections** absent in all tissues. **Extracellular crystalline pigment** bright red-brown in water and in Melzer's reagent but dissolves in KOH, occurs in the pileipellis, and in all tramal tissues, but is particularly abundant near the tube openings and the scales on the stipe.

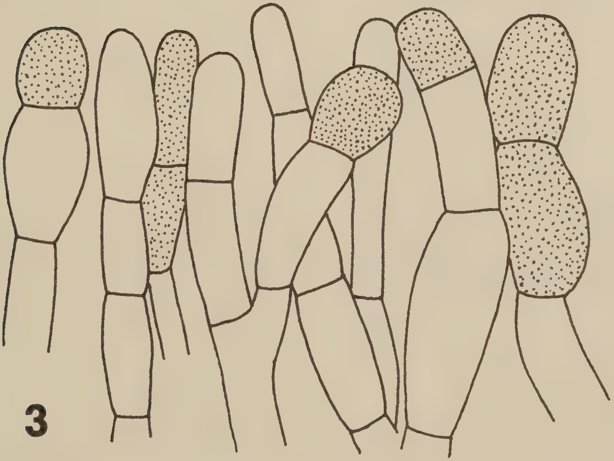
Figs. 1, 2, 3. *Leccinum australiense* holotype:
1. basidiomes - juvenile on left, bar scale = 10mm. 2. basidiospores. 3. pileipellis. Bar scale for Figs. 2 & 3 = 10µm.



1

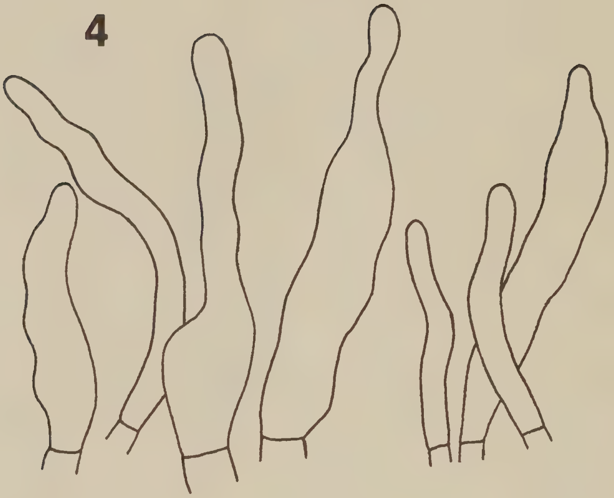


2

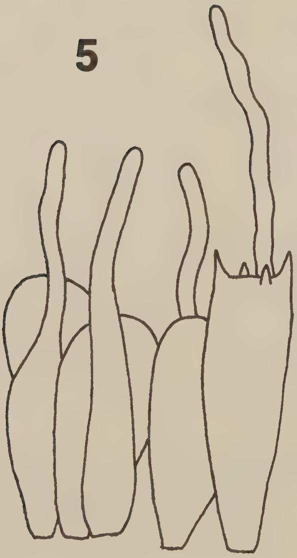


3

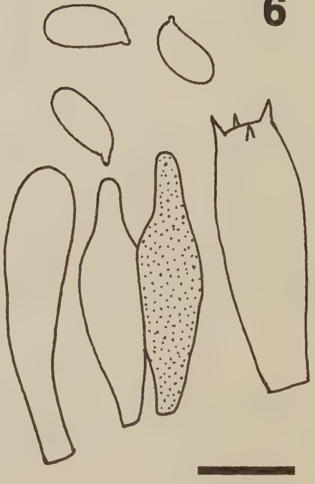
4



5



6



Habitat among litter in mature *Eucalyptus grandis* Hill ex Maid. forests, in north Queensland, Australia.
Material examined (i) Koombooloomba area, northern Queensland (Lat. 17° 50' S., Long. 145° 32' E.), near side of track in red loam soil under a stand of mature *Eucalyptus grandis* trees, 4 May 1988, N. Bougher and N. Malajczuk, holotype BRIP 17542; isotype E4010 (in SFU). (ii) Davies Creek Road, northern Queensland (Lat. 17° 04' S., Long. 145° 36' E.), in litter under *Eucalyptus grandis* trees, 5 April 1989, M. Castellano, paratype BRIP 17543.

DISCUSSION

The presence of sterile extensions of the pileipellis beyond the margin of the hymenophore readily places this species in section *Leccinum*. The dark pigmentation of the pileus and stipe indicate that it probably belongs in subsection *Obscura* (Smith *et al.*, 1981). The very dark reddish brown color of the pileus and stipe are very distinctive and easily distinguish *L. australiense* from most other species. There are no species in the Northern Hemisphere known to us with this heavy pigmentation. It may possibly be related to or confused with *L. intusrubens* from Malaysia and Japan (see Corner, 1972; Hongo, 1983), but the context of the stipe and pileus of that species turns strongly red when exposed and the pigmentation of the pileus and stipe is more nearly grayish to gray black, somewhat suggestive of *L. griseum* (Quél.) Sing. In addition, the surface of the stipe of *L. intusrubens* is longitudinally rugulose.

Another interesting characteristic of *L. australiense* is the presence of a reddish to brown pigment which is released most noticeably from the cells of the pileipellis when mounted in KOH or Melzer's reagent. We know of no other species in which such a pigment has been reported.

Figs. 4, 5, 6. *Leccinum australiense* holotype:
4. cheilocystidia. 5. pleurocystidia and a basidium. 6. caulocystidia, a caulobasidium and basidiospores produced on the stipe. Bar scale = 10µm.

ACKNOWLEDGEMENTS

The authors thank Ellen Thiers for the Latin translation. Also A.K. Mills, C.A. Grgurinovic and M.A. Castellano for critically reviewing the manuscript. Work was carried out during a project sponsored by the Australian Centre for International Agricultural Research.

LITERATURE CITED

CORNER, E. J. (1972). Boletus in Malaysia. Government Printing Office, Singapore. Pp. 102-107.

HONGO, T. (1960). The Agaricales of Japan I - 2. Acta Phytotax. Geobot. 18: 97-112.

HONGO, T. (1973). Enumeration of the Hygrophoraceae, Boletaceae and Strobilomycetaceae. Bull. Natn. Sci. Mus. Tokyo 16: 537-557.

HONGO, T. (1983). Notulae Mycologicae (18). Mem. Fac. Educ. Shiga Univ. Nat. Sci. 33: 37-41.

HONGO, T. and E. NAGASAWA (1977). Notes on some boleti from Tottori III. Rept. Tottori Mycol. Inst. (Japan) 15: 50-54.

HONGO, T. and K. YOKOYAMA (1976). Materials for the fungus flora of Japan (22). Trans. mycol. Soc. Japan 17: 140-143.

KORNERUP, A. and J. H. WANSCHER (1978). Methuen Handbook of Colour. 3rd Ed. Methuen & Co. Ltd., London.

PEGLER, D. N. (1977). A preliminary Agaric Flora of East Africa. Kew Bull. Addit. Ser. VI. Royal Botanic Garden, Kew. Pp. 564-566.

SMITH, A. H., SMITH H. V. and N. S. WEBER (1981). How to know the Non-Gilled Fungi. 2nd Ed. Wm. C. Brown Co., Dubuque, IA. Pp. 184-200.

WATLING, R. and N. M. GREGORY (1988). Observations on the boletes of the Cooloola Sandmass, Queensland and notes on their distribution in Australia. Part 2A. smooth spored taxa - introduction, keys and references. Proc. R. Soc. Qld. 99: 45-63.

MYCOTAXON

Volume XLII, pp. 263-296 October-December 1991

ON LICHENICOLOUS FUNGI FROM CONTINENTAL NORTH AMERICA

D. TRIEBEL[1], G. RAMBOLD[1] & T.H. NASH III[2]

[1] Botanische Staatssammlung, Menzinger Str. 67, D-8000 München 19, F.R.G.
[2] Dept. of Botany, Arizona State University, Tempe, AZ 85287-1601, U.S.A.

ABSTRACT: An annotated list of lichenicolous fungi from continental North America is presented. The fifty-eight taxa listed (fifty-three ascomycetes and five coelomycetes) include two species new to science: *Lichenochora xanthoriae* Triebel & Rambold and *Sphaerellothecium subtile* Triebel & Rambold. Two combinations are made: *Arthonia subfuscicola* (Lindsay) Triebel [bas. *Microthelia subfuscicola* Lindsay] and *Stigmidium congestum* (Koerb.) Triebel [bas. *Pharcidia congesta* Koerb.]. Twenty-seven lichenicolous fungi are reported as new for the flora of continental North America. Additional host species are reported for twenty-three taxa.

KEYWORDS: Lichenicolous fungi, flora of continental North America, *Arthonia subfuscicola*, *Lichenochora xanthoriae*, *Sphaerellothecium subtile*, *Stigmidium congestum*.

INTRODUCTION

In spite of increasing efforts in studying lichenicolous fungi, the distribution of these organisms is still rather poorly known. EGAN (1987, 1989, 1990) reported only sixty-two taxa from North America and a few additional taxa are mentioned by ALSTRUP & HAWKSWORTH (1990), CLAUZADE et al. (1989), GRUBE & HAFELLNER (1990), HAWKSWORTH (1977, 1979, 1981), HENSSEN (1963, 1977), RAMBOLD & TRIEBEL (1990), SHERWOOD-PIKE (1986) and TRIEBEL (1989). Altogether these reports include seventy-eight taxa of ascomycetes, fourteen deuteromycetes and one lichenicolous basidiomycete.

The following annotated list of lichenicolous fungi is based on material, collected mainly in the southwestern and southern part of North America. The fifty-eight taxa listed here (fifty-three ascomycetes and five coelomycetes), include twenty-seven, which are new for the flora of continental North America and are marked by '*'. These new records bring the total of known lichenicolous fungi in North America to 120. Many additional taxa are likely to be found.

Most of these fungi are widely distributed and determinable by various existing keys and modern descriptions. Censequently, detailed descriptions are not made hereafter, but references to appropriate literature are given. All specimens are housed in the lichenological herbarium of the Arizona State University, Tempe, AZ (ASU). The nomenclature of the lichenized taxa mainly follows EGAN (1987, 1989, 1990).

We would like to thank Prof. Dr. H. Hertel (Munich) and Dr. B.D. Ryan (Tempe) for various help. Particular thanks are due to Prof. Dr. R. Santesson (Uppsala) for revising the manuscript and comments on the distribution of several species. For financial support we gratefully acknowledge grant BSR-8820016 from the U.S. National Science Foundation to Arizona State University.

THE SPECIES

Abrothallus bertianus DeNot.

This species is known to grow on representatives of *Melanelia*, *Nephroma*, *Pseudephebe*, and *Xanthoparmelia*. The vegetative hyphae usually react I_{Lugol} + blue, but this feature was not observable in the North American specimen cited below. A similar lack of reaction was also observed in R. SANTESSON, Fungi Lichenicoli Exs. No. 1: *Abrothallus bertianus* on *Melanelia olivacea* (L.) Essl. (M).
Distribution: Europe, North America*; South America (Peru) - SANTESSON (in litt.).
Sel. lit: ALSTRUP & HAWKSWORTH (1990), CLAUZADE & al. (1989).

Specimen: U.S.A., ARIZONA: Cochise Co., Chiricahua Mtns, Rustlers Park, 2590 m, over rocks, [on *Xanthoparmelia somloensis* (Gyelnik) Hale], 6 IV 1972, T.H. Nash III 3867.

Abrothallus parmeliarum (Sommerf.) Arnold

This common fungus occurs on various representatives of *Parmelia* s. str. The vegetative hyphae are generally not reacting in Lugol's solution.
Distribution: Widespread in the extra-tropical regions of the world.
Sel. lit: ALSTRUP & HAWKSWORTH (1990), CLAUZADE et al. (1989).

Specimen: U.S.A., ARIZONA: Pima Co., Santa Catalina Mtns, along Sabino Creek below Marshall Gulch picnic grounds, 2260 m, 32°25'30''N, 110°45'30''W, on *Alnus*, [on *Parmelia sulcata* Th. Tayl.], 18 IX 1983, T.H. Nash III 21173.

Abrothallus peyritschii (Stein) Kotte

The species is restricted to *Tuckermannopsis pinastri* (Scop.) Hale and has somewhat smaller spores than the closely related *A. bertianus*. The I_{Lugol}+ blue reacting vegetative hyphae are characteristic for both species and were observed in the North American specimen cited below.
Distribution: Europe, North America*, and Australasia (New Zealand).
Sel. lit: CLAUZADE et al. (1989).

Specimen: CANADA, ALBERTA: 5.6 km NE of Ma-Me-O-Beach, on spruce twigs in low woods, [on *T. pinastri*], 2 VI 1959, G.H. Turner 10548.

Abrothallus prodiens (Harm.) Diederich & Hafellner

The specimen cited below shows the characteristic substipitate pseudothecia and KOH-reactions as mentioned by DIEDERICH (1990) and has spores of 11 - 14 × 5 - 6 µm. *Cavernularia* is a new host genus.
Distribution: Europe, North America*.
Sel. lit: CLAUZADE et al. (1989), DIEDERICH (1990).

Specimen: U.S.A., CALIFORNIA: Mendocino Co., Pigmy forest adjacent county airport, 140 m, 39°21'N, 123°42'W, on *Cupressus* sp., [on *Cavernularia lophyrea* (Ach.) Degel.], 13 VIII 1988, T.H. Nash III 25492.

Adelococcus alpestris (Zopf) Theiss. & H. Sydow

This species was known to grow on *Acarospora glaucocarpa* (Ach.) Koerb. and *A. macrospora* (Hepp) Bagl. The spores of the specimen cited below

are somewhat narrower than given in MATZER & HAFELLNER (5 - 5.5 µm in comparison to 7 - 13 µm breadth). *Acarospora fuscata* Nyl.(Arnold) is a new host.
Distribution: Europe, Greenland, North America*.
Sel. lit: ALSTRUP & HAWKSWORTH (1990), MATZER & HAFELLNER (1990).

Specimen: MEXICO: Baja California Sur, 53 km SW of Loreto, on volcanic rock, [on *A. fuscata*], 28 V 1974, T.H. Nash III 8891.

Arthonia clemens (Tul.) Th. Fr.

A. clemens parasitizes several species of the *Lecanora dispersa*-group, *Rhizoplaca chrysoleuca* (Sm.) Zopf, *R. peltata* (DC.) Leuckert & Poelt, and was found by ALSTRUP & HAWKSWORTH (1990) also on *Protoparmelia badia* (Hoffm.) Hafellner and *Psoroma hypnorum* (Vahl) Gray. The infection of the fungus is recognized easily by the blackish coloration of the host apothecia. We follow a species concept, which includes specimens with a colorless hypothecium and specimens with a more or less pigmented hypothecium. *A. clemens* has 1-septate, soleiform spores.
Distribution: Europe, North Africa, Greenland, North America*, and Asia (China).
Sel. lit: ALSTRUP & HAWKSWORTH (1990), CLAUZADE et al. (1989), TRIEBEL (1989).

Specimens: U.S.A., COLORADO: San Juan Co., Mesa Verde National Park, Soda Canyon and Battleship Rock area, pinyon-juniper community, 2150-2270 m, 37°14'30''N, 108°30'W, on Cliff House sandstone, [on *Lecanora dispersa* (Pers.) Sommerf.], 29 V 1980, T.H. Nash III 18062. – NEW MEXICO: Valencia Co., Acoma Indian Reservation, rest area along I-40, c. 32 km SE of Grants, 1920 m, 35°03'N, 107°42'W, on sandstone, [on *R. chrysoleuca*], 18 VIII 1979, L. Sigal & T.H. Nash III 16000. – ARIZONA: Coconino Co., Kaibab National Forest, 18 km N of Jacob Lake, pinyon-juniper habitat, 1890 m, 36°51'N, 110°55'W, on sandstone, [on *L. dispersa*], 20 VII 1983, T.H. Nash III 21269.

Arthonia epiphyscia Nyl.

The species occurs on members of the Pyxinaceae and the Teloschistaceae, and produces ascomata on both the vegetative thallus and the apothecia of the host. It is characterized by its I_{Lugol}+ red hymenium, a dark brown hypothecium, 4 - 5 µm thick apical cells of the paraphysoids, and 1-septate,

soleiform spores of 10 - 14 × 3.5 - 5 µm. The analyzed specimens, growing on *Phaeophyscia hirsuta* (Mereschk.) Moberg have somewhat larger spores.
Distribution: Europe, Greenland, North America*, South America, South Africa, and the Antarctic island Bouvetøya.
Sel. lit: ALSTRUP & HAWKSWORTH (1990), CLAUZADE et al. (1989).

Specimens: U.S.A., ARIZONA: Gila Co., cliff area above Roosevelt Lake along route 288 to Young, [on *P. hirsuta*], 20 I 1991, T.H. Nash III 28556, 28557.

Arthonia glaucomaria Nyl.

The species grows in the apothecia of the *Lecanora rupicola*-group, which turn black by the infection. *A. glaucomaria* is characterized by 3-septate spores.
Distribution: Widespread in montane regions of the world; *A. glaucomaria* s. str. (excl. *A. intexta*) is new for North America*.
Sel. lit: ALSTRUP & HAWKSWORTH (1990), CLAUZADE et al. (1989), HERTEL (1969).

Specimens: U.S.A., ARIZONA: Gila Co., Workman Falls area of the Sierra Ancha Experimental Forest, [on *L. rupicola* (L.) Zahlbr.], 19 I 1991, T.H. Nash III 28473. – Santa Cruz Co., Santa Rita Mtns, along trail in vicinity of Bellow Springs, 2300-2500 m, 31°42'N, 110°51'30''W, on siliceous rock, [on *L. rupicola*], IV 1982, T.H. Nash III 19556.

Arthonia intexta Almqu.

This frequently overlooked species occurs commonly in the hymenium of saxicolous species of *Lecidella*, mostly in *L. stigmatea* (Ach.) Hertel & Leuck. agg. The discs of the infected apothecia have an irregular and rough surface and mostly are convex. In comparison to other hymeniicolous representatives of the genus *Arthonia*, the thecial elements of *A. intexta* are relatively scarce. The spores are mostly 2-septate (rarely 3-septate). Because J.-G. Knoph and Ch. Leuckert are currently monographing the North American species of *Lecidella*, the hosts are determined just to genus level.
Distribution: Probably with worldwide distribution: reports exist from Europe, North Africa, North and Central America, and Australia.
Sel. lit: HERTEL (1969), TRIEBEL (1989).

Specimens: U.S.A., MINNESOTA: Cook Co., Temperance River State Park, on outcrops along Lake Superior shore, 47°33'N, 90°52'W, [on *Lecidella* sp.], 7 VII 1976, R.A. Anderson 9763.

– CALIFORNIA: Inyo Co., White Mountains, Inyo, along state 168, near Westgard Pass, c. 1830 m, on schist, [on *Lecidella* sp.], 18 VIII 1973, T.H. Nash III 8086. – NEW MEXICO: San Juan Co., S side of Chaco Wash across from Casa Chiquita Ruins near a coal mine, 1890 m, 36°03'N, 107°59'W, on Cliff House sandstone, [on *Lecidella* sp.], 7 VIII 1979, L. Sigal & T.H. Nash III 16268. – San Juan Co., M 41, 1585 m, 36°40'N, 108°30'W, on sandstone, [on *Lecidella* sp.], 24 VII 1974, J. Marsh 13 & D. Rankert. – San Juan Co., M 72, 1645 m, 36°41'N, 108°25'W, on sandstone, [on *Lecidella* sp.], 30 VII 1974, J. Marsh 333 & D. Rankert.

Arthonia subfuscicola (Lindsay) Triebel **comb. nov.**

≡ *Microthelia subfuscicola* Lindsay, Quat. J. Micr. Sci. II, **11**: 39 (1871).
Type: GREAT BRITAIN, SCOTLAND: S. Aberdeen, Braemar Morrone, [on *Lecanora carpinea* (L.) Vain.], VIII 1856, W.L. Lindsay (E, holotype) - [according to HAWKSWORTH (1985: 167)].
= *Celidium varians* var. *pallidae* Rehm in Arnold, Lich. Exs. 376 (?1867-1870) - nomen nudum.
≡ *Celidium varians* f. *pallidae* Rehm in Arnold, Flora **57**: 106 (1874) - nomen nudum.
≡ *Arthonia glaucomaria* var. *pallidae* Rehm ex Almqu., Kongl. Svenska Vetenskapsakad. Handl. **17**(6): 60 (1880).
Type: GERMANY: Bavaria: Mittelfranken, bei Obernesselbach unweit Sugenheim, an dürren Ästen alter Birnbäume, [on *Lecanora albella* (Pers.) Ach.], 1867, leg. H. Rehm (ARNOLD, Lich. Exs. 376; M!, lectotype, isolectotype - designated here).

The species is similar to *A. glaucomaria*, which is restricted to the apothecia of the saxicolous *Lecanora rupicola* group. In contrast, this species occurs on the apothecia and on the vegetative thallus of the corticolous host lichens *Lecanora albella* (Pers.) Ach. [= *L. pallida* (Schreb.) Rabenh.] and *L. carpinea*.
Distribution: Europe (British Isles, Scandinavia, Central Europe) (see ALMQUIST 1880 and NORRLIN & NYLANDER, Herb. Lich. Fenniae 231), North America*.
Sel. lit: ALMQUIST (1880), HAWKSWORTH (1985: 167).

Specimen: U.S.A., ARIZONA: Pima Co., Santa Catalina Mtns, top of Mt Lemmon, 2740 m, [on *L. carpinea*], 23 III 1972, T.H. Nash III 4043.

Buellia badia (Fr.) Massal.

At its juvenile stage, *B. badia* is endokapylic (i.e. without visible vegetative thallus or thalline, respectively algae-containing margins of the apothecia). It mostly starts growing on various genera of the Parmeliaceae, e.g.

Melanelia, *Neofuscelia*, *Paraparmelia*, *Xanthoparmelia* and is also found on *Acarospora*, *Aspicilia*, *Caloplaca* and *Rinodina*. Later, *B. badia* develops a nitid brown thallus and becomes independent. *Buellia* is a new host genus for this species.
Distribution: Widespread; known from Europe, Africa, Australasia and North America.
Sel. lit: HAFELLNER (1979), TRIEBEL (1987).

Specimen: U.S.A., ARIZONA: Cochise Co., Chiricahua Mtns, Southwest Research Station, limestone wash, 1645 m, [on *Buellia spuria* (Schaer.) Anzi], 6 IV 1972, T.H. Nash III 3663.

Carbonea vitellinaria (Nyl.) Hertel

This species occurs in the montane to alpine regions and is restricted to saxicolous, muscicolous and corticolous species of *Candelariella*. *C. rosulans* (Müll. Arg.) Zahlbr., *C. terrigena* Räs., and *C. xanthostigma* (Ach.) Lettau, are reported as new host species.
Distribution: Widespread in the montane to alpine regions of the world.
Sel. lit: ALSTRUP & HAWKSWORTH (1990), CLAUZADE & al. (1989), HAFELLNER & SANCHO (1990).

Specimens: CANADA, ALBERTA: Oldman River Watershed, Waterton Lakes National Park, beside Alderson Creek, between Upper and Middle Carthew Lakes, 2160 m, on rock, NE-facing outcrop, [on *C. vitellina* (Hoffm.) Müll. Arg.], 27 VII 1966, C.D. Bird & E.J. Lakusta 17130. – U.S.A., WYOMING: Park Co., Yellowstone National Park, S side of Bunsen Peak, 2400 m, 44°41'N, 110°42'W, on *Pseudotsuga menziesii*, [on *C. xanthostigma*], 28 VII 1983, T.H. Nash III 21536. – Sheridan Co., Big Horn Mtns, 1 km WSW of Burgess Junction, 2470 m, 44°46'N, 107°32'W, on acidic rock, [on *C. rosulans*], 2 VIII 1983, T.H. Nash III 21793. – UTAH: Iron Co., Cedar Breaks National Monument, c. 3170 m, 37°36'06''N, 112°50'28''W, on rhyolite, [on *Candelariella* sp.], [n.d.], G. Nebecker 2234. – CALIFORNIA: Inyo Co., Sierra Nevada Mtns, 15 km S of Tom's Place, along Rock Creek Road, Eastern Brook Lakes Watershed, 3410 m, 37°26'N, 118°44'30''W, on granidiorite, alpine area on top of southern shoulder, [on *C. vitellina*], VI 1984, B.D. Ryan 12735. – Inyo Co., Inyo National Forest, Eastern Brooks Watershed, 3170 m, 37°26'N, 118°44'30''W, on granite, [on *C. terrigena*], 21 VII 1984, T.H. Nash III 22749. – ARIZONA: Coconino Co., N to NE slope on Mt Agassiz in the San Francisco Peaks, 3540 m, 35°19'N, 111°40'W, above timerline, [on *C. vitellina*], 24 IX 1988, T.H. Nash III 25429. – MEXICO: Baja California del Norte, near observatory, about 100 km E of San Telmo, top of San Pedro Martirs, 2800 m, 31°00'N, 115°25'W, [on *Candelariella* sp.], 16 V 1977, T.H. Nash III 14722.

Cercidospora epicarphinea (Nyl.) Grube & Hafellner
incl. *Cercidospora caudata* Kernst.

The species has 1-septate, basally acuminate to tailed spores. It is restricted to representatives of *Caloplaca*, *Xanthoria* and *Xanthopeltis*. *C. modesta* (Zahlbr.) Fink is a new host.
Distribution: Europe, Canary Islands, Greenland, North America*, and South America.
Sel. lit: ALSTRUP & HAWKSWORTH (1990), CLAUZADE et al. (1989), GRUBE & HAFELLNER (1990), HAFELLNER (1987), KEISSLER (1930), SANTESSON (1949).

Specimens: U.S.A., ARIZONA: Maricopa Co., McDowell Mtns Regional Park, Upper Sonoran Desert scrub, E-facing slopes, c. 670 m, [on *C. modesta*], 10 I 1976, T.H. Nash III & M.A. Lane 1884. – Maricopa Co., 26 km E of Apache Junction, Hwy 88, S side, on rock, 700 m, [on *C. modesta*], IX 1979, A. Olafsen 124. – Maricopa Co., N side of Eagle Eye Butte, 5.6 km S of Aguila, on volcanic rock, c. 790 m, [on *C. modesta*], 17 II 1975, T.H. Nash III 9968.

Cercidospora epipolytropa (Mudd) Arnold

This species grows on the vegetative thallus and the apothecia of *Lecanora polytropa* agg. Its ascomata appear as bluish-black dots in the stereomicroscope. The spores are 1-septate, basally attenuate.
Distribution: Montane to alpine regions of Europe, Greenland, North America, North Africa, and Asia.
Sel. lit: ALSTRUP & HAWKSWORTH (1990), HAFELLNER (1987).

Specimens: U.S.A., WYOMING: Fremont Co., Wind River Range, Shoshone National Forest, along Stough Creek Lakes Trail, c. 3000 m, 42°41'N, 109°01'W, on granite at Stough Pass, [on *L. polytropa* (Hoffm.) Rabenh.], 24 VII 1983, T.H. Nash III 21397. – ARIZONA: Apache Co., Escudilla Mtn, N of Alpine, spruce-fir community, 3200 m, on volcanic rock, [on *L. polytropa*], 30 VIII 1975, T.H. Nash III 11763. – Coconino Co., San Francisco peaks, Arizona Snow Bowl, Engelmann Spruce forest near base of ski lift, 2925-3170 m, 35°20'N, 111°42'W, [on *L. polytropa*], 16 VI 1974, S. Tucker 12534B.

Cercidospora ulothii Koerb.

C. ulothii is very similar to the preceeding species, from which it differs by its larger spores, and a different host spectrum. While *C. epipolytropa* occurs on representatives of the *Lecanora polytropa*-group, *C. ulothii* is

restricted to members of *Lecanora* subgen. *Placodium*. *Lecanora christoi* W. Weber and *L. novomexicana* H. Magn. are new hosts.
Distribution: Europe (incl. Spitsbergen), Greenland, North America, ? Asia (China).
Sel. lit: ALSTRUP & HAWKSWORTH (1990), HAFELLNER (1987).

Specimens: CANADA, ALBERTA: E side of Alberta Hwy 6, 25 km N of Twin Buttes (3 km S of Pincher Creek), 1220 m, 49°23'N, 113°55'W, on exposed sandstone, [on *Lecanora muralis* (Schreb.) Rabenh.], 27 VII 1985, B.D. Ryan 13937. – Ibidem, [on *Lecanora garovaglii* (Koerb.) Zahlbr.], 27 VII 1985, B.D. Ryan 13939, 13947. – U.S.A., OREGON: Lake Co., 8 km E of Quartz Mtn, Drews Creek Oregon Hwy 140, 1585 m, 42°17'N, 120°45'30''W, [on *L. christoi*], 28 VI 1985, B.D. Ryan 13856. – COLORADO: Garfield Co., E side of Hwy 13, 7 km N of Rifle, c. 1700 m, 39°35'N, 107°46'30''W, [on *L. novomexicana*], VIII 1985, B.D. Ryan 20687. – UTAH: Grand Co., State Hwy 128, NE of Moab, above Colorado River, 43 km NE of junction with Hwy 160, 1300 m, 38°45'N, 109°20'W, [on *L. muralis*], VII 1985, B.D. Ryan 11639. – NEVADA: Lincoln Co., along Hwy 93, c. 42 km S of Alamo, c. 950 m, 37°15'N, 115°W, [on *L. garovaglii*], I 1986, B.D. Ryan 15765. – CALIFORNIA: Mono Co., Brooks Range, Rock Creek Canyon leading up to Eastern Brooks Lake, 2680 m, 37°29'N, 118°43'W, [on *Lecanora* (*Placodium*) sp.], 21 VII 1984, B.D. Ryan 12510. – ARIZONA: Apache Co., W end of Querino Wash, just S of Interstate Hwy 40, 9 km W of Houck, c. 1900 m, 35°14'N, 109°16'W, [on *L. muralis*], III 1986, B.D. Ryan 19172.

Clypeococcum hypocenomyceae D. Hawksw.

C. hypocenomyceae is one of the few lichenicolous fungi, which seriously damage the host thallus. It is restricted to *Hypocenomyce scalaris* (Ach.) Choisy, where it produces immersed ascomata, occurring in groups and united by a dark colored clypeus.
Distribution: Europe, North America.
Sel. lit: CLAUZADE et al. (1989), HAWKSWORTH (1980), TRIEBEL (1989).

Specimen: U.S.A., MINNESOTA: Lake Co., 2 km NW of Illgen City, 8 km NE of Silver Bay, on Hwy 1, on S-facing rocky hillside in second growth aspens, [on *H. scalaris*], 9 VIII 1976, C.M. Wetmore 26323.

Dactylospora amygdalariae Triebel

This common lichenicolous fungus occurs on the arctic-alpine species of *Amygdalaria*, preferable on *A. elegantior* (H. Magn.) Hertel & Brodo and *A. panaeola* (Ach.) Hertel & Brodo. It has a similar, but smaller host-spectrum than *D. purpurascens* Triebel, which is found on various representatives of

Amygdalaria and other Porpidiaceae as well as *Pilophorus*, also in nordic reagions. *D. purpurascens* is recognizable by the K + purple color reaction of the thecial pigments and by larger, thin-walled spores.
Distribution: Europe (incl. Spitsbergen), Greenland, North America, Asia.
Sel. lit: TRIEBEL (1989).

Specimens: U.S.A., ALASKA: Denali Hwy, c. 72 km W of Paxson, 63°07'N, 146°30'W, on siliceous rock, [on *A. panaeola*], 22 VI 1977, T.H. Nash III 14642. – North Slope Borough Co., Brooks Range, Anaktuvuk Pass, 700 m, 68°08'N, 151°45'W, on non-calcareous rock, [on *A. elegantior*], VII 1976, T. Moser & T.H. Nash III 13084.

Dactylospora deminuta (Th.Fr.) Triebel

The species occurs in arctic-alpine habitats and prefers to grow on muscicolous crustose hosts, especially on *Biatora* species. It has 3-7-septate spores and a pale brown to middle brown hypothecium, usually with inspersed dark violet-blue granules. The most related species, with up to just 5-septate spores and a darker hypothecial pigmentation, is *D. urceolata* (Th. Fr.) Arnold, growing on *Protothelenella sphinctrinoides* (Nyl.) Mayrh. & Poelt.
Distribution: Europe (incl. Spitsbergen), and North America*.
Sel. lit: TRIEBEL (1989).

Specimen: U.S.A., MICHIGAN: Isle Royale National Park, N of Conglomerate Bay, on ridge around ledges in mixed forest of birch, aspen, spruce and balsam fir, [on *Biatora vernalis* (L.) Fr.], 25 VII 1983, C.M. Wetmore 49477.

Dactylospora glaucomarioides (Willey ex Tuck.) Hafellner

Like *D. deminuta* and *D. urceolata*, *D. glaucomarioides* usually has more-than-four-celled spores. Hafellner (1979) reports this species from Massachusetts and North Carolina on *Ochrolechia tartarea* (L.) Massal. and *O. yasudae* Vain. With this report from Colorado the host spectrum now includes also *O. upsaliensis* (L.) Massal.
Distribution: North America.
Sel. lit: HAFELLNER (1979).

Specimen: U.S.A., COLORADO: El Paso Co., 0.8 km W of Palmer Lake, N slope, forest, on soil and *Selaginella*, [on *O. upsaliensis*], 22 VII 1954, S. Shushan S 2859.

Dactylospora saxatilis (Schaer.) Hafellner var. **saxatilis**

This very common species occurs on saxicolous *Pertusaria* species, especially *P. flavicans* Lamy. *Pertusaria arizonica* Dibben is a new host. *D. saxatilis* is closely related to *D. amygdalariae*, which has smaller spores and a different host spectrum.
Distribution: Europe, Greenland, North America, North Africa.
Sel. lit: ALSTRUP & HAWKSWORTH (1990), CLAUZADE et al. (1989), HAFELLNER (1979).

Specimens: U.S.A., ARIZONA: Santa Cruz Co., Coronado National Forest hills just S of Pena Blanca Lake along state Rte 289, 1160 m, on rock, [on *P. arizonica*], 30 XII 1972, T.H. Nash III 6077. – Santa Cruz Co., Sycamore Canyon, c. 32 km W of Nogales, 1160 m, 31°25'N, 111°12'W, on rhyolite, [on *P. arizonica*], 27 III 1976, T.H. Nash III 13016.

Echinothecium reticulatum Zopf

The species is restricted to various genera of Parmeliaceae. It is characterized by the brown hair-like protrusions of the perithecioid pseudothecia and its 1-septate, hyaline spores. Similar to *Sphaerellothecium* species, it forms a conspicuous reticulum of thick-walled brown torulose hyphae spreading over the surface of the host lichen.
Distribution: Europe, Greenland, North America; South America (Peru) - SANTESSON (in litt.).
Sel. lit: ALSTRUP & HAWKSWORTH (1990), KEISSLER (1930), TRIEBEL (1989).

Specimen: U.S.A., ARIZONA: Cochise Co., Chiricahua Mtns, Bearfoot Park, 2500 m, on rocks above scree slope, [on *Flavoparmelia caperata* (L.) Hale], 6 IV 1972, T.H. Nash III 3812.

Endococcus perpusillus Nyl.

The species is characterized by its thin-walled, narrow spores (13 - 21 × 5 - 8 µm) and is easily to distinguish from *E. propinquus* and *E. rugulosus* by these spore characters together with a different host spectrum. *Dimelaena oreina* (Ach.) Norm. is a new host.
Distribution: The species was recently reported as new for North America (North Carolina, Virginia) by TRIEBEL (1989). Known also from Europe and

Australasia (New Zealand); probably worldwide distributed in extra-tropical regions.
Sel. lit: TRIEBEL (1989).

Specimens: U.S.A., ARIZONA: Coconino Co., San Francisco Peaks, Agassiz Peak, NW slope, 3660 m, on volcanic rock, [on *Rhizocarpon geographicum* (L.) DC.], 14 VII 1973, T.H. Nash III 7569. – Gila Co., Mazatal Mtns, Mt. Ord, 2160 m, [on *D. oreina*], 31 VII 1974, T.H. Nash III 9203. – Graham Co., Pinaleno Mtns, Route 366, 1220 m, pinyon-juniper grasslands, [on *Dimelaena* sp.], 7 IV 1972, T.H. Nash III 4185.

Endococcus propinquus (Koerb.) D. Hawksw.

E. propinquus has ovoid, thick-walled spores of 8.5 - 12.5 × 5 - 7 µm and most frequently grows on members of *Porpidia*. The species delimitation of *E. propinquus* in TRIEBEL (1989), which is also chosen here, is narrower than that chosen by most other authors before. *Carbonea* and *Physcia* are reported as new host genera.
Distribution: Probably in all extra-tropical regions of the world; known from Europe, Greenland, North America, South America, Asia, and Australasia (Australia).
Sel. lit: TRIEBEL (1989).

Specimens: U.S.A., ALASKA: St Paul Island, 7 m, 57°20'N, 170°15'W, on volcanic rock, [on *Porpidia macrocarpa* (DC.) Hertel & Schwab], 16 VII 1976, T.H. Nash III 13490. – COLORADO: Hinsdale Co., along trail to W of Rio Grande Reservoir, spruce forest area, 2870-3000 m, 37°46'30''N, 107°21'30''W, [on *Porpidia speirea* (Ach.) Kremp.], 12 VIII 1984, T.H. Nash III 25714. – El Paso Co., Pikes Peak, just S of Teller County, 4150 m, 38°50'N, 105°02'W, on granite, [on *Tephromela armeniaca* (DC.) Hertel & Rambold], 10 VIII 1984, T.H. Nash III 25814. – Summit Co., slope above Blue Lakes Reservoir Dam and SW of Hoosier Pass, c. 3475 m, 39°23'N, 106°05'30''W, on siliceous rock, [on *T. armeniaca*], 17 VIII 1983, T.H. Nash III 22186. – TEXAS: Jeff Davis Co., 10.5 km SE of Fort Dan's along state 118 in a mesquite grassland, 1463 m, on volcanic rock, [on *Physcia* cf. *phaea* (Tuck.) Thomson], 24 III 1973, T.H. Nash III 6575. – ARIZONA: Coconino Co., W side of San Francisco Peaks near road to Snow Bowl, 2680 m, on volcanic rock, [on *T. armeniaca*], 14 VII 1973, T.H. Nash III 7468. – Apache Co., W side of Escudilla Mtn, 10 km N of Alpine, pine-fir forest, 3000 m, on basalt, [on *Carbonea* sp.], 21 V 1975, T.H. Nash III 10772.

Endococcus rugulosus Nyl.

The spores of *E. rugulosus* are in shape and thickness of wall like those of *E. propinquus*, but are somewhat larger (13 - 16 × 6 - 7.5 µm). *Acarospora nitida* H. Magn. is a new host.
Distribution: Probably worldwide in extra-tropical regions; reports exist from Europe, (incl. Spitsbergen), Greenland, North America, Asia, and Australasia (New Zealand).
Sel. lit: TRIEBEL (1989).

Specimens: U.S.A., OREGON: Baker Co., Magpie Peak, c. 20 km NW of Baker, 44°55'N, 117°40'W, [on *Acarospora* sp. (with brown thallus)], 1986, F. Palmer [s.n.]. – COLORADO: Clear Creek Co., saddle below Mt Evans, 4020 m, 39°34'30''N, 105°37'30''W, on granite, [on *A. nitida*], 16 VIII 1983, T.H. Nash III 22099.

Epilichen stellatus Triebel

The apothecia of this lecanoralean species typically have a distinct margin and a plane disc. They occur on both the vegetative thallus and the ascocarps of the host lichen. The asci belong to the *Rhizocarpon*- or *Lecidea*-type. Hitherto only known from the type collection from Asia, *E. stellatus* seems to be rather common on *Lecidea tessellata* Flk. in North America.
Distribution: Asia (U.S.S.R., Chukchi Peninsula), North America*.
Sel. lit: TRIEBEL (1989).

Specimens: CANADA, NOVA SCOTIA: Halifax Co., Duncan's Cove, 24 km SE of Halifax, c. 30 m, 44°30'N, 63°32'W, on heath and shallow open bogs over rock on coast, [on *L. tessellata*], 18 VI 1972, I.M. Brodo 18858. – U.S.A., COLORADO: San Juan Co., Mesa Verde National Park, Upper Fewkes Canyon, 2070 m, 37°10'N, 108°28'30''W, on Cliff House sandstone, [on *L. tessellata*], 28 V 1980, T.H. Nash III 17873. – Hinsdale Co., along trail to W of Rio Grande Reservoir, spruce forest area, 2870-3000 m, 37°46'30''N, 107°21'30''W, on acidic rock, [on *L. tessellata*], 12 VIII 1984, T.H. Nash III 25717. – UTAH: Daggett Co., 27 km S of Manila, ponderosa pine zone, on sandstone, [on *L. tessellata*], 14 VIII 1974, T.H. Nash III 10474. – San Juan Co., N across Hwy 666 from the Monticello Dump, c. 2520 m, 37°52'N, 109°20'W, on porphyritic intrusive rock, [on *L. tessellata*], [n.d.], G. Nebecker 2610. – ARIZONA: Coconino Co., Grand Canyon National Park, south rim, Bright Angel Trail, 1680 m, on Supai sandstone, [on *L. tessellata*], 12 X 1974, T.H. Nash III 9573. – Cochise Co., Chiricahua Mtns, SW Research Station to Rustlers Park, 1650 m, limestone area, [on *L. tessellata*], 6 IV 1972, T.H. Nash III 3689. – Greenlee Co., 31 km N of Morenci, along U.S. 666, 2140 m, pinyon-juniper-oak area, on volcanic rock, [on *L. tessellata*], 24 VII 1973, T.H. Nash III 7676. – Pima Co., Santa Catalina Mtns, large boulder outcrop area, 2140 m, on large boulder, [on *L. tessellata*], 23 III 1972, T.H. Nash III 4074. – Pima Co., Santa Catalina Mtns, Mt Bigelow, S side of Butterfly Peak, 2560 m, 32°24'30''N, 110°43'W, on granite, [on *L. tessellata*], 27 V 1983, T.H. Nash III 20718. – MEXICO: Durango, along Rte 40 between Durango and Mazatlan, 8 km W of La Cuidad, pine-oak-madrono forest, 2610 m, 23°41'N, 105°44'W, on rock, [on *L. tessellata*], 15 VI 1976, T.H. Nash III 13931.

Karschia inops Triebel & Rambold in R. Sant., Fungi Lichenicoli Exs. No. 167 (in press).

Description: Ascomata: apothecioid, black, at first immersed, closed, then opening to expose a flat disc, sessile, 0.15 - 0.2 mm (- 0.25 mm) diam., dispersed on the vegetatve thallus and the apothecia of saxicolous *Caloplaca* species. Excipulum: c. 25 - 30 µm thick, outer part dark brown, inner part pale brown, composed of pseudoparenchymateous cells, 5 -7 µm (lumina 3 - 4 µm) diam. Hypothecium: hyaline or pale brown, stipitate. Hymenium: hyaline, 45 - 55 µm tall. Paraphysoids scarce, branched and anastomosed, 2.5 - 3 µm (lumina 1.5 - 2 µm) thick, apical cells brown pigmented, up to 6 µm (lumina up to 4 µm) thick. Epihymenium dark brown, c. 10 µm tall. Asci: bitunicate-fissitunicate, with distinct ocular chamber, broadly clavate, 34 - 50 × 14 - 17 µm, 8-spored. Ascospores: ellipsoid, 1-septate, rarely 2-3-septate, constricted at the septum, thin-walled, smooth-walled, remaining hyaline for a long time, finally pale brown, (13 -) 16 - 17 (- 18) × 6 - 8 (- 8.5) µm. Vegetative hyphae: some brown hyphae visible near the basis of the ascomata, up to 5 µm diam. Color reactions: hymenial gel I_{Lugol} + pale blue or -.

This is a second report of *Karschia inops*.The species has recently been described from Australia, growing on *Caloplaca cinnabarina* (Ach.) Zahlbr. *Caloplaca modesta* (Zahlbr.) Fink is a new host. In contrast to the type collection, the North American specimens show a slightly bluish reaction in iodine. The closely related genera *Buelliella* and *Karschia* seem to be not rare in the subtropical and tropical regions. Until now six species of *Buelliella* and three species of *Karschia* are known [see ALSTRUP & HAWKSWORTH (1990), HAFELLNER (1979, 1986), KALB (1990) and TRIEBEL (1989)].

Distribution: Australia, North America*.

Sel. lit: SANTESSON, Fungi Lichenicoli Exs. No. 167 (in press).

Specimens: U.S.A., ARIZONA: Maricopa Co., Camelback Mtn, Paradise Valley, N-facing slope, E side, 550 m, 33°31'N, 111°57'W, on conglomerate, [on *C. modesta*], 22 XII 1972, T.H. Nash III 6132. – Maricopa Co., 26 km E of Apache Junction, Hwy 88, S side, on rock, 700 m, [on

C. modesta], IX 1979, A. Olafsen 124. – Maricopa Co., N of Carefree, on rock, [on *C. modesta*], 13 I 1975, T.H. Nash III 9845.

Lichenochora xanthoriae Triebel & Rambold **sp. nov.**

Diagnosis: Ascosporae (10.5 -) 12 - 15 (- 16) µm longae, 8 - 9 (- 9.5) µm latae, late ellipsoideae. Crescit in thallo apotheciisque *Xanthoriae elegantis* et hoc cecidia causit. Ceterum cum *Lichenochora thallina* (Cooke) Hafellner congruit.
Holotype: U.S.A., UTAH: San Juan Co., S side of Navajo Mtn, pinyon-juniper area, on sandstone, 2170 m, [on *Xanthoria elegans* (Link) Th. Fr.], 24 IX 1973, T.H. Nash III 8235 (ASU).

Description: Perithecia: densely aggregated, completely immersed (only as small black dots in the stereomicroscope visible), obpyriform, c. 200 - 250 µm long, c. 175 - 200 µm broad. Perithecium wall brown, around the ostiolum darker pigmented than at the basis, c. 20 - 30 µm thick, pseudoparenchymatous (textura angularis). Cells tangentialiter flattened, c. 10 - 15 × 4 - 5 µm. Hamathecium: periphyses numerous, mostly hyaline, c. 25 - 35 µm long and 2 - 4 µm broad; some filamentous hyphae visible between the young asci (c. 3 µm broad). Asci: cylindrical, unitunicate, thin-walled, c. 78 - 85 × 9 - 12 µm, 8-spored. Ascospores: uniseriate, 1-septate, hyaline, smooth-walled, broadly ellipsoid, (10.5 -) 12 - 15 (- 16) × 8 - 9 (- 9.5) µm. Vegetative hyphae: some brownish hyphae (c. 4 - 5 µm diam.) near the basis of the perithecia visible. Color reactions: I_{Lugol} epiplasma + orange ("dextrinoid reaction"), KOH -.
Numerous lipid drops were found in all parts of the perithecium, what is regarded to be a characteristic of this recently described genus of the Phyllachorales (HAFELLNER 1989).

This lichenicolous fungus grows on the vegetative thallus and the apothecia of *Xanthoria elegans*, causing small galls. From the other members of *Lichenochora*, the species is distinguished by its broadly ellipsoid, non-verrucose, hyaline spores and its occurrence on *Xanthoria*.
Distribution: North America* (only known from the type collection).

Lichenoconium lecanorae (Jaap) D. Hawksw.

This coelomycete occurs on many genera of the Lecanorales, especially on species of the Lecanoraceae and the Parmeliaceae.
Distribution: Europe and North America.

Sel. lit: ALSTRUP & HAWKSWORTH (1990), CLAUZADE et al. (1989), HAWKSWORTH (1977 - sub *L. parasiticum*).

Specimens: U.S.A., ARIZONA: Apache Co., Sunrise Ski Area, Fort Apache Reservation, 2810 m, Spruce-fir forest, on *Abies* twig, [on *Parmelia sulcata* Th. Tayl.], 29 VIII 1975, T.H. Nash III 11679. – Greenlee Co., Hannangan Meadows, along U.S. 666, 2770 m, on *Abies concolor*, [on *Lecanora chlarotera* Nyl. (apothecia)], 24 VII 1973, T.H. Nash III 7700.

Lichenoconium pyxidatae (Oudem.) Petrak & H. Sydow

This species occurs on the podetia and the squamules of various representatives of *Cladonia* and *Cladina*.
Distribution: Europe, North America*.
Sel. lit: CLAUZADE et al. (1989), DIEDERICH (1986), HAWKSWORTH (1977).

Specimen: U.S.A., ARIZONA: Cochise Co., Chiricahua Mtns, Bearfoot Park, 2500 m, scree slope area among rocks, [on *Cladonia pyxidata* (L.) Hoffm. (podetia)], 6 IV 1972, T.H. Nash III 3802.

Lichenoconium xanthoriae M.S. Christ.

L. xanthoriae occurs on genera of the Teloschistaceae (previously known only on *Xanthoria* species) and Parmeliaceae (*Melanelia* and *Tuckermannopsis*). *Teloschistes* is reported as a new host genus, where *L. xanthoriae* is found growing on both the apothecia and the vegetative thallus.
Distribution: Europe, North America*.
Sel. lit: CLAUZADE et al. (1989), DIEDERICH et al. (1991), HAWKSWORTH (1977).

Specimen: MEXICO: Sonora, 9 km NE of Puerto Chale, c. 20 m, 24°31'N, 111°29'W, on *Fouquieria diguetii*, [on *T. chrysophthalmus* (L.) Th.Fr.], 29 V 1979, T.H. Nash III 17066.

Lichenodiplis lecanorae (Vouaux) Dyko & D. Hawksw.

This coelomycete occurs in the apothecia and on the vegetative thallus of *Caloplaca*, *Evernia*, *Lecanora*, *Pertusaria*, *Rhizoplaca*, and *Xanthoria* species. The conidia were sometimes misinterpreted as ascospores of *Muellerella lichenicola* because of their similar shape, color and size.

However, the basal ends of the *Lichenodiplis* conidia are squared-off due to their mode of development.
Distribution: Europe, North Africa, Canary Islands, Greenland, North America*; South America (Argentinia) - SANTESSON (in litt.).
Sel. lit: ALSTRUP & HAWKSWORTH (1990), CLAUZADE et al. (1989), HAWKSWORTH & DYKO (1979).

Specimen: U.S.A., ARIZONA: Gila Co., N to NE side of Four Peaks near the Maricopa County line, 2150 m, 33°40'N, 111°18'W, on *Juniperus deppeana* wood, [on *Caloplaca cerina* (Ehrh. ex Hedwig) Th. Fr. (apothecia)], 1 X 1988, T.H. Nash III 25388.

Lichenostigma rugosa Thor

The species occurs on various species of *Diploschistes*. DIEDERICH (1986) suggests, that it becomes lichenized (epikapylic) when living on the apothecia of the host.
Distribution: Europe, Greenland, Asia, North Africa, Middle East region (Libya, Saudi Arabia), and North America.
Sel. lit: ALSTRUP & HAWKSWORTH (1990), DIEDERICH (1986), THOR (1985).

Specimen: U.S.A., ARIZONA: Gila Co., Mazatzal Wilderness Barnhardt Trail W of Mazatzal Peak, 1400-1600 m, 34°05'N, 111°26'W, on volcanic rock, [on *Diploschistes scruposus* (Schreb.) Norm.], 22 IX 1979, T.H. Nash III 16493.

Merismatium decolorans (Rehm ex Arnold) Triebel

M. decolorans is found on several terricolous crustose lichen species. The most related species *M. peregrinum* (Flot.) Triebel occurs in Europe and Asia, where it grows on the saxicolous hosts *Rimularia badioatra* (Kremp.) Hertel & Rambold and on *R. gibbosa* (Ach.) Coppins, Hertel & Rambold (HERTEL & RAMBOLD 1990).
Distribution: Europe, North America.
Sel. lit: TRIEBEL (1989).

Specimens: U.S.A., MINNESOTA: St Louis Co., Voyageurs National Park, Cementery Island in Namakan Lake, in ash bog near eastern end of island with black ash and some old *Thuja*, [on *Mycobilimbia berengeriana* (Massal.) Hafellner & V. Wirth], 9 VI 1978, C.M. Wetmore 32688. – UTAH: San Juan Co., flat top of Navajo Mtn, 3050 m, spruce-fir forest, [on *M. berengeriana*], 17 VIII 1972, T.H. Nash III 5155.

Muellerella lichenicola (Sommerf.: Fr.) D. Hawksw.

This species has extremely small, thin-walled, pale brown ascospores (c. 4.5 - 7 × 2 - 3.5 µm), which exceed 64 per ascus. Its ascomata frequently are found in the apothecia of the host lichens, which belong to various saxicolous crustose genera, mostly Pyxinaceae and Teloschistaceae.
Distribution: Worldwide in extra-tropical regions, mainly at lower altitudes.
Sel. lit: TRIEBEL (1989).

Specimen: COLORADO: San Juan Co., Mesa Verde National Park, Lower Fewkes Canyon, 2040 m, 37°10'N, 108°28'30''W, on Cliff House sandstone, [on *Caloplaca* cf. *arenaria* (Pers.) Müll. Arg.], 27 V 1980, T.H. Nash III 17787.

Muellerella pygmaea (Koerb.) D. Hawksw. var. **pygmaea**

M. pygmaea grows on more than one hundred mostly saxicolous and crustose host species of various systematic relationships. The spores of the type variety are 7.5 - 13 × 3.5 - 6 µm and mostly c. 32 per ascus. *Acarospora fuscata* (Schrad.) Arnold is reported as a new host of this taxon.
Distribution: Worldwide in extra-tropical regions, mainly at higher altitudes.
Sel. lit: TRIEBEL (1989).

Specimens: U.S.A., ALASKA: North Slope Borough Co., Anaktuvuk Pass in the Endicott Mtns of the Brooks Range, 700 m, 68°08'N, 151°45'W, on non-calcareous rock, [on *Lecidea lapicida* (Ach.) Ach.], VII 1976, T.H. Nash III 13283. – COLORADO: San Juan Co., Mesa Verde National Park, Upper Fewkes Canyon, 2070 m, 37°10'N, 108°28'30''W, on Cliff House sandstone, [on *A. fuscata*], 28 V 1980, T.H. Nash III 17829. – UTAH: Iron Co., Cedar Breaks National Monument, c. 3170 m, 37°36'06''N, 112°50'28''W, on rhyolite, [on *Lecidea atrobrunnea* (Ram.) Schaer.], [n.d.], G. Nebecker 2245. – San Juan Co., Navajo Mtn, 3050 m, on sandstone, [on *Lecidea* s. str. sp.], 24 IX 1973, T.H. Nash III 8166. – ARIZONA: Apache Co., N of Alpine, top of Escudilla Mtn, near the lookout tower, 3290 m, spruce-fir community, on volcanic rock, [on *L. atrobrunnea* agg.], 30 VIII 1975, T.H. Nash III 11797.

Muellerella pygmaea var. **athallina** (Müll. Arg.) Triebel

Although *M. pygmaea* var. *athallina* is probably still heterogenous, it differs from the type by smaller, frequently thin-walled spores (5.5 - 8.5 × 2.5 - 5 µm) and a larger number of spores (32 - 64) per ascus. *Acarospora schleicheri* (Ach.) Massal., *Clauzadeana macula* (Th. Tayl.) Coppins & Rambold, and *Lecanora novomexicana* H. Magn. are new hosts. The North American specimens of *M. pygmaea* on *Bellemerea alpina* (Sommerf.)

Clauz. & Roux and *Lecidea tessellata* Flk. are likely to belong to var. *athallina* and not to the type variety.
Distribution: Worldwide in extra-tropical regions.
Sel. lit: TRIEBEL (1989).

Specimens: U.S.A., WYOMING: Park Co., Yellowstone National Park, Mt Washburn, alpine meadow, c. 2900 m, 44°47'30''N, 110°25'W, on volcanic rock, [on *L. tessellata*], 27 VII 1983, T.H. Nash III 21489. – COLORADO: Clear Creek Co., 1.9 km W of Silver Plume, extensive N-facing talus accumulation, 2845-2920 m, [*C. macula*], 5 IX 1976, R.A. Anderson 9973. – Ouray Co., San Juan Mtns, Governor Basin and near Mendota Peak, 9.7 km SW of Ouray, E and NE of Virginius Mine, 3540-3720 m, [on *Lecanora marginata* (Schaer.) Hertel & Rambold], 17 VIII 1966, R.A. Anderson 5908. – La Plata Co., P 26, Red Rock, 1980 m, 37°07'N, 108°10'W, on sandstone, [on *Lecidella* sp.], 8 VII 1974, J. Marsh & D. Rankert. 397. – UTAH: Duchesne Co., Uinta Mtns, S side of Hayden Peak near Utah, 150, 3570 m, on sandstone in rock scree, [on *B. alpina*], 15 VIII 1974, T.H. Nash III 9470. – CALIFORNIA: Los Angeles Co., San Gabriel Wilderness, Survey 25, S-facing slope of Waterman Mtn, 2350 m, 34°20'N, 117°56'W, on white fir, [on *L. tessellata*], 13 X 1989, B.D. Ryan 26596. – NEW MEXICO: San Juan Co., Chaco Canyon National Monument, Charca Mesa S of Wijiji ruins, 1950 m, 36°01'N, 107°52'W, on Cliff House sandstone, [on *L. tessellata*], 6 VIII 1979, L. Sigal & T.H. Nash III 16424. – McKinley Co., Road to Redrock State Park, 4.8 km N of Interstate Hwy 40, c. 8 km E of Gallup, c. 2075 m, 35°35'N, 108°40'W, [on *L. novomexicana*], III 1986, B.D. Ryan 19051. – ARIZONA: Navajo Co., North rim of Black Mesa, 2380 m, 36°40'N, 110°30'W, on sandstone, [on *L. tessellata*], 29 IV 1976, T.H. Nash III 14882. – Coconino Co., Grand Canyon National Park, south rim, Hermit's Rest, pinyon-juniper community, 2010 m, on Kaibab limestone, [on *Lecidella* sp.], 13 X 1974, T.H. Nash 9546. – Apache Co., W side of Escudilla Mtn, 10 km N of Alpine, pine-fir forest, 2990 m, on basalt, [on *Rinodina* sp.], 21 V 1975, T.H. Nash III 10772. – Mohave Co., 32 km W Kingman, Union Pass, Black Mtns, along Rte 68, 1100 m, on schist, [on *A. schleicheri*], 19 II 1973, T.H. Nash III 7317. – Cochise Co., Chiricahua Mtns, Herb Martyr Forest Camp, 1680 m, on limestone along stream, [on *Protoblastenia rupestris* (Scop.) Steiner], 6 IV 1972, T.H. Nash III 3958.

Muellerella pygmaea var. **ventosicola** (Mudd) Triebel

The var. *ventosicola* differs from the type by shorter spores (6.5 - 9 × 4 - 6 µm) and a larger number of spores (32 - 64) per ascus. It mainly grows on *Ophioparma ventosa* (L.) Norm. and on species of *Rhizocarpon* growing on siliceous rock.
Distribution: Worldwide in extra-tropical regions.
Sel. lit: TRIEBEL (1989).

Specimens: U.S.A., COLORADO: Summit Co., slope above Blue Lakes Reservoir Dam and SW of Hoosier Pass, c. 3475 m, 39°23'N, 106°05'30''W, on siliceous rock, [on *Rhizocarpon* sp.], 17 VIII 1983, T.H. Nash III 22199. – ARIZONA: Santa Cruz Co., Santa Rita Mtns, Baldy

Saddle area, 2685 m, 31°42'N, 110°51'W, on cliff-face, [on *Rhizocarpon geographicum* (L.) DC.], 5 X 1981, T.H. Nash III 18579.

Peridiothelia grandiuscula (Anzi) D. Hawksw.

This species is not really lichenicolous, but was found erumpent through the vegetative thallus of *Lecanora impudens* Degel. *P. grandiuscula* lives on the bark of various deciduous trees.
Distribution: Europe, North America*.
Sel. lit: HAWKSWORTH (1985).

Specimens: U.S.A., ARIZONA: Gila Co., Sierra Ancha Experimental Forest, along Workman Creek, 1 km above Young Hwy, 1830 m, 33°52'N, 110°57'W, on *Alnus*, [intermixed with *Lecanora impudens* Degel.], 19 I 1991, T.H. Nash III 28462.

Phacopsis oxyspora (Tul.) Triebel & Rambold

The genus *Phacopsis* is very uniform concerning ascus and paraphyses types and the host spectrum (Parmeliaceae and Usneaceae). Main characters on species level are the shape of the unicellular spores, the development of the excipulum, and the color of the ascocarps. *P. oxyspora* itself is characterized by its brown, roundish, (semi-)immersed apothecia without distinct marginal structures and by the lemon-shaped spores. It causes galls on several genera of the Parmeliaceae. *Cavernularia* is reported as a new host genus.
Distribution: Europe, Asia, Africa, Greenland, North and South America.
Sel. lit: ALSTRUP & HAWKSWORTH (1990), HAFELLNER & SANCHO (1990), TRIEBEL & RAMBOLD (1988).

Specimens: CANADA, BRITISH COLUMBIA: Queen Charlotte Islands, Graham Island, 3.2 km SE of Port Clements, S of the Tlell - Port Clements Rd, 53°40'N, 132°09'W, [on *Cavernularia hultenii* Degel.], 11 VII 1971, I.M. Brodo 18089. – U.S.A., ARIZONA: Coconino Co., Oak Creek Canyon, Pump House Wash, on vertical rock, N-facing, [on *Parmelia sulcata* Th. Tayl.], 26 IX 1971, T.H. Nash III 3507. – Gila Co., Falls area at headwaters of Workman Creek on way to Aztec Peak, 2070 m, 33°49'N, 110°55'W, [on *Parmelia* s.l. sp.], 1 VII 1974, T.H. Nash III 9259. – Gila Co., Sierra Ancha, top of trail along the south fork of Parker Creek above Sierra Ancha Experimental Station, 2000 m, 33°48'N, 110°58'W, [on *Punctelia* sp.], 15 IV 1989, T.H. Nash III 26423. – Cochise Co., Chiricahua Mtns, Bearfoot Park, 2500 m, on exposed boulder, [on *P. sulcata*], 6 IV 1972, T.H. Nash III 3795. – Pima Co., Santa Catalina Mtns, along Sabino Creek below Mashall Gulch picnic grounds, 2260 m, 32°25'30''N, 110°45'30''W, on open granite cliff-face, [on *P. sulcata*], 18 IX 1983, T.H. Nash III 21159.

Polycoccum galligenum Vězda

P. galligenum is a cecidogenous (i.e. gall-inducing) species with characteristic dark brown, strongly verrucose spores. It was hitherto only known to grow on *Physcia caesia* (Hoffm.) Fürnrohr, *P. dubia* (Hoffm.) Lettau, *P. wainioi* Räs., and *Xanthoria elegans* (Link) Th. Fr. The spores of the specimen cited below, are slightly smaller than those in the specimens growing on *Physcia* species. According to DIEDERICH et al. (1991) and our own observations, *P. galligenum* usually lives on saxicolous host lichens like the most species of *Polycoccum* do. The North American specimen is found growing on a *Heterodermia erinacea* (Ach.) Weber on twigs of *Cercidium*. *Heterodermia* is a new host genus.
Distribution: Europe, Greenland, North America*; South America (Peru) and Java - SANTESSON (in litt.).
Sel. lit: ALSTRUP (1991), ALSTRUP & HAWKSWORTH (1990), HAWKSWORTH & DIEDERICH (1988), VĚZDA (1969).

Specimen: MEXICO: Baja California Sur, 24 km E of San Carlos, on old beach ridge, 30 m, on *Cercidium* sp., [on *Heterodermia erinacea*], 18 III 1976, T.H. Nash III 12840B.

Polycoccum sporastatiae (Anzi) Arnold

P. sporastatiae is restricted to the host genus *Sporastatia* and was observed by the authors on *Sporastatia polyspora* (Nyl.) Grumm., *Sp. testudinea* (Ach.) Massal. - and, as a new host - on *Sporastatia asiatica* H. Magn. [East Hindukush, leg. H. Roemer (M)].
Distribution: Europe, Asia, reported as new for North America by TRIEBEL (1989: 79).
Sel. lit: CLAUZADE et al. (1989), HAWKSWORTH & DIEDERICH (1988), TRIEBEL (1989).

Specimen: U.S.A., ARIZONA: Santa Cruz Co., Santa Rita Mtns, along trail in vicinity of Bellow Springs, 2300-2500 m, 31°42'N, 110°51'30''W, on siliceous rock, [on *S. testudinea*], IV 1982, T.H. Nash III 19557.

Polysporina lapponica (Schaer.) Degel.

= *Polysporina dubia* (H. Magn.) Vězda

According to VĚZDA (1970), and POELT & VĚZDA (1981), *P. lapponica* is characterized by its lichenicolous and endokapylic growth type and its spores of 4 - 5.5 × 2 - 3 µm. It is related to the autotrophic species *P. simplex*. The species concept is still preliminary and needs to be revised. The species was hitherto known to grow on saxicolous representatives of *Acarospora*, *Buellia*, and *Lecanora* species. *Candelariella* is a new host genus. Growing on *Candelariella* species., the apothecia of *P. lapponica* habitually resemble those of *Carbonea vitellinaria*, however, frequently have brownish tinged, umbonate discs.
Distribution: Europe, North America*.
Sel. lit: DEGELIUS (1986), NIMIS & POELT (1987), POELT & VĚZDA (1981), VĚZDA (1970).

Specimens: U.S.A., WYOMING: Fremont Co., Wind River Range, Shoshone National Forest, along Stough Creek Lakes Trail, c. 3000 m, 42°41'N, 109°01'W, on granite at Stough Pass, [on *Candelariella* sp.], 24 VII 1983, T.H. Nash III 21397. – ARIZONA: Apache Co., Petrified Forest National Park, 1740 m, 34°49'30''N, 109°49'00''W, on sandstone, [on *Candelariella rosulans* (Müll.Arg.) Zahlbr.], 14 V 1990, B. Davis 724.

Pyrenidium actinellum Nyl.

This fungus has a wide host spectrum including up to now nineteen crustose or foliose lichen species on various types of substrates. Very characteristic for *P. actinellum* are the big dark brown pigmented, 3-septate spores with distinct central pore and pale brown ends. *Acarospora* and *Teloschistes* are reported as new host genera. The cited specimens on *Trapeliopsis granulosa* (Hoffm.) H.T. Lumbsch and *Teloschistes chrysophthalmus* (L.) Th. Fr. show gall-like formations.
Distribution: Probably worldwide, reports exist from Europe, Asia (specimen in M), Greenland, North America*, Jamaica, Africa, and Australia.
Sel. lit: ALSTRUP & HAWKSWORTH (1990), CLAUZADE et al. (1989), HAWKSWORTH (1983a), MIES & LUMBSCH (1990), TRIEBEL (1989).

Specimens: U.S.A., MINNESOTA: St. Louis Co., Voyageurs National Park, point inside Duckfoot Island in Rainy Lake, [on *Baeomyces rufus* (Huds.) Rebent.], 22 VI 1978, C.M.

Wetmore 34134. – ARIZONA: Cochise Co., Chiricahua Mtns, canyon between Herb Martyr Dam and Winn Falls, 1950-2000 m, 31°52'N, 109°15'W, on rotting log, [on *T. granulosa*], 3 X 1981, T.H. Nash III 18464. – MEXICO: Baja California Sur, 22 km WSW of Villa Constitucion, old beach ridge, 30 m, 24°57'N, 111°51'W, on *Fouquieria*, [on *T. chrysophthalmus*], 18 III 1976, T.H. Nash III 12843. – Durango, along Rte 40, 22 km N of Yerbanis, burned over *Acacia-Opuntia*-habitat, 1680 m, 24°53'N, 103°41'W, on volcanic rock, [on *A.* cf. *schleicheri* (Ach.) Massal.], 16 VI 1976, T.H. Nash III 13881.

Rinodina insularis (Arnold) Hafellner

Similar to *Buellia badia*, this lichenicolous species is endokapylic (i.e. without visible vegetative thallus or thalline, respectively algae-containing margins of the apothecia) just at its juvenile stage. It grows on species of the *Lecanora rupicola*-group, has characteristic spores of the "*Physcia*-type" (sensu MAYRHOFER 1984) and develops later an independent small brownish thallus.

Distribution: Europe, North America*, and Australia (specimen in M).

Sel. lit: CLAUZADE et al. (1989), HAFELLNER (1979).

Specimens: U.S.A., ARIZONA: Apache Co., W side of Escudilla Mtn, 10 km N of Alpine, pine-fir forest, 2990 m, on basalt, [on *L. rupicola* agg.], 21 V 1975, T.H. Nash III 10772. – Gila Co., Sierra Ancha Experimental Forest, vicinity of Workman Creek Falls, c. 2000 m, 33°54'N, 110°56'W, [on *L. rupicola* (L.) Zahlbr.], 19 I 1991, T.H. Nash III 28473.

Skyttea elachistophora (Nyl.) Sherw. & D. Hawksw.

S. elachistophora mainly occurs on saxicolous and corticolous host individuals of *Tephromela atra* (Huds.) Hafellner s.l., occasionally causing gall-like deformations. From recent studies of several species of *Skyttea*, one of the authors (D.T.) learned that the ascus apex of this odontotremoid genus has constantly an internal apical beak. Because this feature is not observable in the monotypical genus *Rhymbocarpus* (ascus apex is thickened, but without beak), we now hesitate to synonymize the two genera as proposed by TRIEBEL (1989). Additional material of *Rhymbocarpus* will show, whether this taxon is generically separate or an anatomically reduced member of the genus *Skyttea* with immersed habit.

Distribution: Montane and alpine regions in Europe, Africa, North America*, South America and the Subantarctic Islands.

Sel. lit: SHERWOOD et al. (1981), TRIEBEL (1989).

Specimen: U.S.A., ARIZONA: Apache Co., W side of Escudilla Mtn, 10 km N of Alpine, 3000 m, pine-fir forest, on basalt, [on *T. atra*], 21 V 1975, T.H. Nash III 10776.

Sphaerellothecium abditum Triebel

S. abditum is hitherto known growing on species of *Immersaria* and *Lecidea*. Together with *S. contextum* and *S. subtile* (see below), *S. abditum* belongs to the lichenicolous pyrenomycetes with the smallest ascocarps (40 - 60 µm diam.). *S. contextum* and *S. abditum* are the only fungi, known to grow obligatorily within the epinecral layer of crustose lichens, where they form a characteristical reticulum of dark brown, thick-walled, torulose hyphae. The spores of *S. abditum* are brown, 1-septate and measure c. 9.5 - 10.5 × 5 - 5.5 µm. The genus *Sphaerellothecium* differs from *Echinothecium* by its brown, 1-3-septate spores and pseudothecia lacking hair-like protrusions.
Distribution: Europe, Asia (Nepal), North America*.
Sel. lit: TRIEBEL (1989).

Specimens: CANADA, ALBERTA: Oldman River Watershed, Waterton Lakes National Park, beside Alderson Creek, between Upper and Middle Carthew Lakes, 2160 m, on rock, NE-facing outcrop, [on *Lecidea* s. str. sp.], 27 VII 1966, C.D. Bird & E.J. Lakusta 17130. – U.S.A., WYOMING: Park Co., Yellowstone National Park, top of Bunsen Peak, 2500 m, 44°41'N, 110°42'W, on acidic rock, [on *Lecidea atrobrunnea* (Ram.) Schaer. agg.], 28 VII 1983, T.H. Nash III 21573. – COLORADO: Summit Co., slope above Blue Lakes Reservoir Dam and SW of Hoosier Pass, c. 3475 m, 39°23'N, 106°05'30''W, on siliceous rock, [on *L. atrobrunnea* agg.], 17 VIII 1983, T.H. Nash III 22199. – San Juan Co., San Juan Mtns, 16 km S of Silverton, Lime Creek Campground near U.S. 550, 2590 m, on granite, [on *L. atrobrunnea*], 11 VIII 1974, T.H. Nash III 10376. – UTAH: Iron Co., Cedar Breaks National Monument, c. 3170 m, 37°36'06''N, 112°50'28''W, on rhyolite, [on *Lecidea* s. str. sp.], [n.d.], G. Nebecker 2234, 2245. – CALIFORNIA: Inyo Co., Inyo National Forest, trail to Eastern Brook Lakes Watershed, 3170 m, 37°26'N, 118°44'30''W, [on *Lecidea* s. str. sp.], 21 VII 1984, B.D. Ryan 12445. – Siskiyou Co., edge of Marble Mtn Wilderness, trail through Big Meadows, 1900-2000 m, 41°35'N, 123°03'W, on granite rock, [on *Lecidea* s. str. sp.], 25 VIII 1989, B.D. Ryan 25499. – ARIZONA: Coconino Co., San Francisco Mtns, Mt Humphreys, 3350 m, spruce-fir zone, [on *L. atrobrunnea* agg.], VI 1971, T.H. Nash III 3298.

Sphaerellothecium contextum Triebel

S. contextum differs from *S. abditum* by its larger spores of 11.5 - 14 × 5 - 6.5 µm, ascomata of 50 - 70 µm diam., and a different host spectrum including *Protoparmelia badia* (Hoffm.) Hafellner, *Sporastatia testudinea*

(Ach.) Massal. (as the major host), and *Tephromela armeniaca* (DC.) Hertel & Rambold. *Rhizoplaca melanophthalma* (DC. in Lam. & DC.) Leuck. & Poelt is a new host. On *P. badia* and *R. melanophthalma*, *S. contextum* prefers to grow in the epihymenial gallertic layer of the decaying apothecia.
Distribution: Europe, North America.
Sel. lit: TRIEBEL (1989).

Specimens: U.S.A., WYOMING: Sheridan Co., Big Horn Mtns, 1 km WSW of Burgess Junction, 2470 m, 44°46'N, 107°32'W, on acidic rock, [on *T. armeniaca*], 2 VIII 1983, T.H. Nash III 21790. – COLORADO: Summit Co., slope above Blue Lakes Reservoir Dam and SW of Hoosier Pass, c. 3475 m, 39°23'N, 106°05'30''W, on siliceous rock, [on *S. testudinea*], 17 VIII 1983, T.H. Nash III 22185. – Summit Co., slope above Blue Lakes Reservoir Dam and SW of Hoosier Pass, c. 3475 m, 39°23'N, 106°05'30''W, on siliceous rock, [on *T. armeniaca*], 17 VIII 1983, T.H. Nash III 22186. – El Paso Co., Pikes Peak, just S of Teller Co., 4150 m, 38°50'N, 105°02'W, on granite, [on *T. armeniaca*], 10 VIII 1984, T.H. Nash III 25814. – ARIZONA: Coconino Co., Echo Cliffs, 16 km S of Page, 1950 m, on sandstone, [on *R. melanophthalma* (apothecia)], 22 XII 1971, T.H. Nash III 3618. – Coconino Co., W side of San Francisco Peaks near road to Snow Bowl, 2680 m, on volcanic rock, [on *S. testudinea*], 14 VII 1973, T.H. Nash III 7468. – Santa Cruz Co., Santa Rita Mtns, along trail in vicinity of Bellow Springs, 2300-2500 m, 31°42'N, 110°51'30''W, on siliceous rock, [on *S. testudinea*], IV 1982, T.H. Nash III 19557.

Sphaerellothecium subtile Triebel & Rambold **sp. nov.**

Diagnosis: *Sphaerellothecio abdito* similis est, a qua differt pseudotheciis ascosporisque minoribus et hyphis subtilioribus. Crescit in thallo et apotheciis *Teloschistis chrysophthalmi*.
Holotype: MEXICO: Baja California del Sur, 6 km SE of Santa Rita, along route 1, c. 75 m, 24°34'N, 111°25'W, on *Fouquieria diguetii*, [on *T. chrysophthalmus* (L.) Th.Fr.], 21 XII 1973, P.W. Rundel 8172 (ASU).

Description: Ascomata: perithecioid, growing entirely superficially, black, more or less sphaerical, c. 25 - 35 (- 40) µm diam. Ascomata walls brown, c. 5 - 10 µm thick, of 1 - 2 layers of thick-walled, pseudoparenchymateous cells. Cells tangentialiter somewhat flattened, 4 - 5 × 3 - 4 µm diam. Hamathecium: absent. Asci: broadly saccate, only 2 - 3 developing at one time in each ascoma, thick-walled, bitunicate-fissitunicate, with ocular chamber, c. 16 - 20 × 8 - 9 µm, 8-spored. Ascospores: irregularly distichously arranged in the asci, 1-septate, not or slightly constricted at the septum, brown, smooth-walled, ellipsoid, apices rounded, (6.5 -) 7.5 - 8 (- 8.5) × 3 - 3.5 µm. Vegetative hyphae: superficial, brown, torulose, branched and anastomosed, forming a reticulum. Cells subglobose to quadrangular, dark brown, 4 - 6 µm diam., especially the outer cell wall thickened. Color reactions: Epiplasma I_{Lugol} + orange ("dextrinoid reaction"); KOH -.

S. subtile grows on the vegetative thallus and the apothecia of *Teloschistes chrysophthalmus*. It habitually resembles very much *Sphaerellothecium abditum*, which has thicker vegetative hyphae, larger ascomata and spores, and grows within the epinecral layer of saxicolous, crustose lichens.
Distribution: North America* (Mexico).

Further specimens: MEXICO: Baja California Sur, W of San Ignascio, on *Fouquieria* sp., [on *T. chrysophthalmus*], 30 V 1974, T.H. Nash III 8968. – 9 km NE of Puerto Chale, c. 20 m, 24°31'N, 111°29'W, on *Fouquieria diguetii*, [on *T. chrysophthalmus*], 29 V 1979, T.H. Nash III 17066.

Sphinctrina anglica Nyl.

S. anglica is found on a corticolous *Lecanora* species and on sterile thalli of an unidentified brownish crustose lichens on bark.
Distribution: Temperate areas in the Northern Hemisphere.
Sel. lit: CLAUZADE et al. (1989), LÖFGREN & TIBELL (1979), TIBELL (1984).

Specimen: U.S.A., MINNESOTA: St. Louis Co., Voyageurs National Park, NE of Wolf Point in Crane Lake, around stepp rock cliffs with some pines on top, [on sterile, crustose lichen thallus], 16 VII 1979, C.M. Wetmore 40319.

Sphinctrina tubaeformis Massal.

The species is restricted to representatives of *Pertusaria*.
Distribution: Warm temperate to subtropical areas in both hemispheres.
Sel. lit: CLAUZADE et al. (1989), LÖFGREN & TIBELL (1979), TIBELL (1984).

Specimen: MEXICO, Baja California Sur, 9 km NE of Puerto Chale, c. 20 m, 24°31'N, 111°29'W, [on *Pertusaria* sp.], 28 V 1979, T.H. Nash III 17059.

Sphinctrina turbinata (Pers.) DeNot.

The species is restricted to representatives of *Pertusaria*.
Distribution: Temperate regions of the Northern Hemisphere, Australasia (Tasmania).

Sel. lit: CLAUZADE et al. (1989), LÖFGREN & TIBELL (1979), TIBELL (1984).

Specimen: U.S.A., MINNESOTA: Cook Co., Sawbill Lake near campground, 37 km N of Tofte, near shore in mixed conifer hardwood forest, [on *Pertusaria* sp.], 28 VI 1974, C.M. Wetmore 22165.

Stigmidium atryneae (Arnold) Hafellner

= *Pharcidia squamariae* B. de Lesd., Bull. Soc. Bot. Fr. 56: 477 (1909). Type: MEXICO: Puébla [Tepoxuchil, alt 2270 m - fide protologue], [on *Lecanora muralis* agg.], 1906, F.A. Brouard [s.n.], (B, ? holotype).

The ascomata of this species grow on the apothecia of saxicolous representatives of *Lecanora*. It resembles very much *St. schaereri* (Massal.) Trev., which grows on the vegetative thallus of the terricolous *Dacampia hookeri* sensu Poelt (? = *Solorina* sp.) and *St. congestum*, growing on the apothecia of corticolous *Lecanora subfusca* agg. Both have sligthly longer spores. Hitherto *St. atryneae* was found on *Lecanora cenisia* Ach. and *L. swartzii* (Ach.) Ach. (= *L. subradiosa* auct.). Reports exist mostly under the name *Stigmidium schaereri*. As *Pharcidia squamariae*, growing on *Lecanora muralis* agg., it is known from Mexico. *L. bipruinosa* Fink s.l., *L. novomexicana* H. Magn., and *L. phaedrophthalma* Poelt are new hosts.
Distribution: Europe (incl. Spitsbergen), North America.
Sel. lit: ARNOLD (1882), HAFELLNER (1982), NIMIS & POELT (1987).

Specimens: U.S.A., COLORADO: Moffat Co., E side of Hwy 13, 26 km N of Axial, c. 1875 m, 40°24'N, 107°38'30''W, sagebrush community, W-facing hill, sandstone outcrops, [on *L. phaedrophthalma*], VIII 1985, B.D. Ryan 20627. – NEW MEXICO: McKinley Co., road to Redrock State Park, 5 km N of Interstate Hwy 40, c. 8 km E of Gallup, c. 2075 m, 35°35'N, 108°40'W, [on *L. novomexicana*], III 1986, B.D. Ryan 19051. – Coconino Co., Echo Cliffs, 16 km SSW of Page along U.S. 89, on sandstone, 1650 m, [on *L. phaedrophthalma*], 23 IV 1973, T.H. Nash III 6526. – Maricopa Co., McDowell Mtns Regional Park, upper Sonoran Desert scrub, E-facing slopes, c. 670 m, [on *L. muralis* agg.], 10 I 1976, T.H. Nash III & M.A. Lane 1862. – MEXICO: Sonora, 5 km N of Moctezuma, on E side of the Sierra la Cienguita, 790 m, 29°46'N, 109°43'W, [on *L. bipruinosa* s.l.], II 1987, B.D. Ryan 21746. - MEXICO: Sonora, 27 km E of Mazacahui, along road to Moctezuma, 975 m, 29°43'30''N, 109°49'W, [on *L. bipruinosa* s.l.], 22 II 1987, B.D. Ryan 21627.

Stigmidium congestum (Koerb.) Triebel **comb. nov.**

≡ *Pharcidia congesta* Koerb., Parerga Lichenologica: 470 (1865). [Holotype in L - fide SANTESSON (1960)].

Reports of this common species exist mainly under the name *St. schaereri*. It is found on the apothecia and rarely on the vegetative thallus of corticolous *Lecanora* species [i.e. *L. carpinea* (L.) Vain., *L. intumescens* (Rebent.) Rabenh., *L. pulicaris* (Pers.) Ach.].
Distribution: Europe, North America*.
Sel. lit: DIEDERICH (1986), KOERBER (1865), SANTESSON (1960).

Specimen: U.S.A, ARIZONA: Apache Co., Escudilla Mtn, N of Alpine, 3200 m, spruce-fir community, on *Abies lasiocarpa*, [on *L. pulicaris*], 30 VIII 1975, T.H. Nash III 11758.

Stigmidium fuscatae (Arnold) R. Sant.

St. fuscatae seems to be a frequent lichenicolous fungus in arid regions, growing on *Acarospora* species. Its ascocarps are sessile, black and globose and are frequently placed in rows along the margins of the host areoles. *A. schleicheri* (Ach.) Massal. is reported as a new host.
Distribution: Europe, North America*; South Africa - SANTESSON (in litt.).
Sel. lit: CLAUZADE et al. (1989), SANTESSON (1988).

Specimens: U.S.A., ARIZONA: Apache Co., Petrified Forest National Park, 1740 m, 34°49'30''N, 109°49'00''W, on sandstone, [on *Acarospora* sp. (brown thallus)], 14 V 1990, B. Davis 724. – Maricopa Co., Bellmont Mtn, 40 km SSW of Wickenburg, 580 m, on schist, [on *A. schleicheri*], 17 II 1975, T.H. Nash III 9987. – Maricopa Co., Camelback Mtns, Paradise Valley, N-facing slope, E side, 550 m, on granite, [on *A. schleicheri*], 22 XII 1972, T.H. Nash III 6126. – Maricopa Co., White Tank Mtns, county regional park, on granite, [on *A. fuscata* (Schrad.) Arnold], 19 I 1975, T.H. Nash III 9819. – Maricopa Co., Guadelupe Canyon, South Mtn, upland Sonoran Desert, 450 m, on granite, [on *A.* cf. *schleicheri*], 30 IX 1981, T.H. Nash III 18448. – Maricopa Co., junction of I-8 and Freeman Rd, 550 m, on rock, [on *A.* cf. *schleicheri*], 10 I 1975, T.H. Nash III 9919. – Maricopa Co., junction of I-8 and Freeman Rd, 550 m, on rock, [on *A. schleicheri*], 10 I 1975, T.H. Nash III 9917.– Pima Co., W side of Tucson Mtns, NW-facing slope, 910 m, on volcanic rock, [on *A.* cf. *schleicheri*], 29 XII 1972, T.H. Nash III 6200. – Pima Co., Organ Pipe Cactus National Monument, 6 km E of visitors center, along Ajo Mtn Drive, 550 m, on volcanic rock, [on *A. fuscata*], 24 XI 1972, T.H. Nash III 6027. – MEXICO: Sonora, 5 km N of Moctezuma, on E side of the Sierra la Cienguito, 790 m, 29°46'N, 109°43'W, [on *A.* cf. *schleicheri*], II 1987, B.D. Ryan 21745. – Sonora, 34 km W of Sonoyta along Rte 2, 31°58'N, 113°09'W, 370 m, on basalt, [on *A. fuscata*], 24 X 1975, T.H. Nash III 11898.

Stigmidium psorae (Anzi) Hafellner

This species seems to be restricted to *Psora crenata* (Th. Tayl.) Reinke and *P. decipiens* (Hedw.) Hoffm.
Distribution: Europe, Asia (Afghanistan) and North America.
Sel lit: TRIEBEL (1989).

Specimens: CANADA, ALBERTA: North Saskatchewan River Watershed, N side of Bighorn Reservoir, beside David Thompson Hwy, 1370 m, 52°15'N, 116°24'W, S-facing slopes with scattered *Pinus flexilis*, on soil, [on *P. decipiens*], 19 VI 1971, G.F. Otto 3611. – U.S.A., ARIZONA: Maricopa Co., Usury Mtns, 32 km E of Phoenix, on soil, [on *P. decipiens*], 22 XI 1971, T.H. Nash III 5023.

Stigmidium tabacinae (Arnold) Triebel

= *Arthopyrenia glebarum* Arnold
≡ *Stigmidium glebarum* (Arnold) Hafellner

The species is restricted to the host genus *Toninia*, where it was hitherto found to be densely scattered on the vegetative thalli of *Toninia caeruleonigricans* (Leightf.) Th. Fr., *T. candida* (Web.) Th. Fr., and *Toninia tristis* (Th. Fr.) Th. Fr. [= *Psora tabacina* s. auct.].
Distribution: Europe, North America*.
Sel. lit: CLAUZADE et al. (1989), NIMIS & POELT (1987), TRIEBEL (1989).

Specimens: U.S.A., NEW MEXICO: San Juan Co., Chaco Canyon National Monument, S side of Chaco Canyon just S of Casa Rinonada ruins, 1920 m, 36°03'N, 107°58'W, on soil, [on *T. tristis*], 6 VIII 1979, L. Sigal & T.H. Nash III 16368. – ARIZONA: Navajo Co., Black Mesa, north rim, 2380 m, 36°40'N, 110°30'W, on soil, [on *T. tristis*], 29 IV 1976, T.H. Nash III 14907.

Thamnogalla crombiei (Mudd) D. Hawksw.

This cecidogenous, i.e. gall-inducing, fungus is easily to be recognized by the hyaline, non-septate spores in unitunicate asci, the occurrence of unbranched paraphyses, and the pinkish brown coloration of the ascomata wall around the ostiolum. It was placed into the Phyllachoraceae (Phyllachorales) by HAFELLNER & SANCHO (1990). The species is restricted to *Thamnolia*.

Distribution: Europe, North America; South America (Colombia, Peru) - SANTESSON (in litt.).
Sel. lit: CLAUZADE et al. (1989), HAFELLNER & SANCHO (1990), HAWKSWORTH (1980).

Specimens: U.S.A., WYOMING: Park Co., Beartooth Plateau area around Beartooth Pass of U.S. no. 212, Shoshone National Forest, c. 3350 m, 44°58'N, 109°28'W, [on *T. subuliformis* (Ehrh.) W. Culb.], 7 VIII 1972, R.J. Naskali 810. – COLORADO: Larimer Co., Rocky Mtn National Park, Mummy Range, NW slope of Mt Chapin, 3650-3780 m, [on *T. subuliformis*], 6 VIII 1966, R.A. Anderson 5707. – Larimer Co., Rocky Mtn National Park, alpine tundra of Trail Ridge NW and W of Toll Memorial, E of Iceberg Pass, 3650 m, 40°25'N, 105°44'W, [on *T. subuliformis*], 4 VIII 1984, T.H. Nash III 23023. – Clear Creek Co., saddle below Mt Evans, 4020 m, 39°34'30''N, 105°37'30''W, [on *T. subuliformis*], 16 VIII 1983, T.H. Nash III 22120.

Vouauxiomyces truncatus (B. de Lesd.) Dyko & D. Hawksw.

The black, semi-immersed pycnidia represent the anamorph of *Abrothallus microspermus* Tul.
Distribution: Europe, North America*.
Sel. lit: CLAUZADE et al. (1989), HAWKSWORTH (1983b).

Specimen: U.S.A., ARIZONA: Cochise Co., Chiricahua Mtns, Bearfoot Park, scree slope, 2500 m, on rock, [on *Flavoparmelia caperata* (L.) Hale], 6 IV 1972, T.H. Nash III 3792.

LITERATURE

ALSTRUP, V. 1991. Lichens and lichenicolous fungi from the Torneträsk area. - Graphis Scripta **3**: 54 - 67.

ALSTRUP, V. & HAWKSWORTH, D. L. 1990. The lichenicolous fungi of Greenland. - Meddelelser om Grønland, Bioscience **31**: 1 - 90.

ARNOLD, F. 1882. Lichenologische Fragmente XXVII. - Flora **65**: 403 - 411, tab. VIII.

CLAUZADE, G., DIEDERICH, P. & ROUX, C. 1989. Nelikeniĝintaj fungoj likenloĝaj. Ilustrita determinlibro. - Bull. Soc. Linn. Provence, Numéro spécial, **1**: 1 - 142.

DEGELIUS, G. 1986. The lichen flora of the island of Anholt, Denmark. - Acta Regiae Soc. Scient. Litt. Gothoburgensis, Bot. **3**: 1 - 60.

DIEDERICH, P. 1986. Lichenicolous fungi from the Grand Duchy of Luxembourg and surrounding areas. - Lejeunia, N. S., **119**: 1 - 26.

DIEDERICH, P. 1990. New or interesting lichenicolous fungi 1. Species from Luxembourg. - Mycotaxon **37**: 297 - 330.

DIEDERICH, P., SÉRUSIAUX, E. & BOOM, P. van den 1991. Lichens et champignons lichénicoles nouveaux ou intéressants pour la flore de la belgique et des regions voisines. V. - Lejeunia **136**: 1 - 47.

EGAN, R.S. 1987. A fifth checklist of the lichen-forming, lichenicolous and allied fungi of the continental United States and Canada. - The Bryologist **90**: 77 - 173.

EGAN, R.S. 1989. Changes to the "Fifth checklist of the lichen-forming, lichenicolous and allied fungi of the continental United States and Canada." Edition I. - The Bryologist **92**: 68 - 72.

EGAN, R.S. 1990. Changes to the "Fifth checklist of the lichen-forming, lichenicolous and allied fungi of the continental United States and Canada." Edition II. - The Bryologist **93**: 211 - 219.

GRUBE, M. & HAFELLNER, J. 1990. Studien an flechtenbewohnenden Pilzen der Sammelgattung *Didymella* (Ascomycetes, Dothideales). - Nova Hedwigia **51**: 283 - 360.

HAFELLNER, J. 1979. *Karschia*. Revision einer Sammelgattung an der Grenze von lichenisierten und nichtlichenisierten Ascomyceten. - Beih. Nova Hedwigia **62**: 1 - 248.

HAFELLNER, J. 1982. Flechtenfunde im Bockfjord, Spitzbergen (Botanische Ergebnisse der österreichischen Spitzbergen-Expedition 1979, I). - Phyton (Austria) **22**: 23 - 50.

HAFELLNER, J. 1986 ["1985"]. Studien über lichenicole Pilze und Flechten IV. Die auf *Brigantiaea*-Arten beobachteten Ascomyceten. - Herzogia **7**: 163 - 180.

HAFELLNER, J. 1987. Studien über lichenicole Pilze und Flechten VI. Ein verändertes Gattungskonzept für *Cercidospora*. - Herzogia **7**: 353 - 362.

HAFELLNER, J. 1989. Studien über lichenicole Pilze und Flechten VII. - Über die neue Gattung *Lichenochora* (Ascomycetes, Phyllachorales). - Nova Hedwigia **48**: 357 - 370.

HAFELLNER, J. & SANCHO, L. G. 1990. Über einige lichenicole Pilze und Flechten aus den Gebirgen Zentralspaniens und den Ostalpen. - Herzogia **8**: 363 - 382.

HAWKSWORTH, D.L. 1977. Taxonomic and biological observations on the genus *Lichenoconium* (Sphaeropsidales). - Persoonia **9**: 159 - 198.

HAWKSWORTH, D.L. 1979. The lichenicolous Hyphomycetes. - Bull. Brit. Mus. (Nat. Hist.) Bot. **6** (3): 183 - 300.

HAWKSWORTH, D.L. 1980. Notes on British lichenicolous fungi: III. - Notes Roy. Bot. Gard. Edinburgh **38**: 165 - 183.

HAWKSWORTH, D.L. 1981. The lichenicolous Coelomycetes. - Bull. Brit. Mus. (Nat. Hist.) Bot. **9** (1): 1 - 98.

HAWKSWORTH, D.L. 1983a. The identity of *Pyrenidium actinellum* Nyl. - Trans. Brit. Mycol. Soc. **80**: 547 - 549.

HAWKSWORTH, D.L. 1983b. A key to the lichen-forming, parasitic, parasymbiotic and saprophytic fungi occurring on lichens in the British Isles. - Lichenologist **15**: 1 - 44.

HAWKSWORTH, D.L. 1985. A redisposition of the species referred to the ascomycete genus *Microthelia* Körber. - Bull. Brit. Mus.(Nat. Hist.) Bot. **14**: 43 - 181.

HAWKSWORTH, D.L. & DIEDERICH, P. 1988. A synopsis of the genus *Polycoccum* (Dothideales), with a key to accepted species. - Trans. Brit. Mycol. Soc. **90**: 293 - 312.

HAWKSWORTH, D.L. & DYKO, B.J. 1979. *Lichenodiplis* and *Vouauxiomyces*: two new genera of lichenicolous Coelomycetes. - Lichenologist **11**: 51 - 61.

HENSSEN, A. 1963. Eine Revision der Flechtenfamilien Lichinaceae und Ephebaceae. - Symb. Bot. Upsal. **18** (1): 1 - 123.

HENSSEN, A. 1977. The genus *Zahlbrucknerella*. - Lichenologist **9**: 17 - 46.

HERTEL, H. 1969. *Arthonia intexta* Almqu., ein vielfach verkannter fruchtkörperloser Flechtenparasit. - Ber. Deutsch. Bot. Ges. **82**: 209-220.

HERTEL, H. & RAMBOLD, G. 1990. Zur Kenntnis der Familie Rimulariaceae (Lecanorales). - In: JAHNS, H. M. (ed.): Contributions to lichenology in honour of A. Henssen. - Biblioth. Lich. **38**: 145 - 189.

KALB, K. 1990. Lichenes Neotropici ausgegeben von Klaus Kalb. Fascikel XI (No. 451 - 475). - Neumarkt / Opf.: 1 - 12.

KEISSLER, K. von 1930. Die Flechtenparasiten. - In: RABENHORST, L. (ed.): Kryptogamen-Flora von Deutschland, Österreich und der Schweiz, 2. Auflage, **8**: 1 - 712.

KOERBER, G.W. 1865. Parerga lichenologica. - Trewendt, Breslau: 385 - 501.

LÖFGREN, O. & TIBELL, L. 1979. *Sphinctrina* in Europe. - Lichenologist **11**: 109 - 137.

LUMBSCH, H.T. 1989. Die holarktischen Vertreter der Flechtengattung *Diploschistes* (Thelotremataceae). - J. Hattori Bot. Lab. **66**: 133 - 196.

MATZER, M. & HAFELLNER, J. 1990. Eine Revision der lichenicolen Arten der Sammelgattung *Rosellinia* (Ascomycetes). - Biblioth. Lich. **37**: 1 - 138.

MAYRHOFER, H. 1984. The saxicolous species of *Dimelaena*, *Rinodina* and *Rinodinella* in Australia. - In: HERTEL, H. & OBERWINKLER, F. (eds.): Festschrift J. Poelt. - Beih. Nova Hedwigia **79**: 511 - 536.

MIES, B. & LUMBSCH, H.T. 1990. Beiträge zur Flechtenflora der Kapverdischen Inseln I. Die Gattung *Diploschistes*. - Nova Hedwigia **51**: 483 - 488.

NIMIS, P.L. & POELT, J. 1987. The lichens and lichenicolous fungi of Sardinia (Italy), an annoted list. - Studia Geobotanica **7**: 1 - 269.

POELT, J. & VĚZDA, A. 1981. Bestimmungsschlüssel europäischer Flechten. Ergänzungsheft II. - Cramer, Vaduz.

RAMBOLD, G. & TRIEBEL, D. 1990. *Gelatinopsis*, *Geltingia* and *Phaeopyxis*: three helotialean genera with lichenicolous species. - Notes Roy.Bot. Gard. Edinburgh **46**: 375 - 389.

SANTESSON, R. 1949. *Dolichocarpus* and *Xanthopeltis*, two new lichen genera from Chile. - Svensk Bot. Tidskr. **43**: 547 - 567.

SANTESSON, R. 1960. Lichenicolous fungi from northern Spain. - Svensk Bot. Tidskr. **54**: 501 - 522.

SANTESSON, R. 1988. Fungi lichenicoli exsiccati. Fasc. 5-6 (Nos 101 - 150), distributed by the Herbarium, University of Uppsala. - Thunbergia **6**: 1 - 18.

SANTESSON, R. in press. Fungi lichenicoli exsiccati. Fasc. 7-8 (Nos. 151 - 200), distributed by the Herbarium, University of Uppsala. - Thunbergia.

SHERWOOD-PIKE, M.A. (1986) ["1985"]. New and unusual ascomycetes from the western United States. - Sydowia, Ann. Mycologici **38**: 267 - 277.

SHERWOOD, M.A., HAWKSWORTH, D.L. & COPPINS, B.J. 1981 ["1980"]. *Skyttea*, a new genus of odontotremoid lichenicolous fungi. - Trans. Brit. Mycol. Soc. **75**: 479-490.

THOR, G. 1985. A new species of *Lichenostigma*, a lichenicolous ascomycete. - Lichenologist **17**: 269 - 272.

TIBELL, L. 1984. A reappraisal of the taxonomy of Caliciales. - In: HERTEL, H. & OBERWINKLER, F. (eds.): Festschrift J. Poelt. - Beih. Nova Hedwigia **79**: 597 - 713.

TRIEBEL, D. 1987. Was ist *Lecidea whakatipae* Knight? - Mitt. Bot. Staatssamml. München **23**: 343 - 344.

TRIEBEL, D. 1989. Lecideicole Ascomyceten - Eine Revision der obligat lichenicolen Ascomyceten auf lecideoiden Flechten. - Biblioth. Lich. **35**: 1 - 278.

TRIEBEL, D. & RAMBOLD, G. 1988. *Cecidonia* und *Phacopsis* (Lecanorales): zwei lichenicole Pilzgattungen mit cecidogenen Arten. - Nova Hedwigia **47**: 279 - 309.

VĚZDA, A. 1969. Beiträge zur Kenntnis der flechtenbewohnenden Pilze in der Tschechoslowakei. II. Zwei neue Arten: *Opegrapha rinodinae* sp. nov. und *Polycoccum galligenum* sp. nov. - Ceská Mykol. **23**: 104 - 109.

VĚZDA, A. 1970. Neue oder wenig bekannte Flechten in der Tschechoslowakei. I. - Folia Geobot. Phytotaxonomica [Praha] **5**: 307 - 337.

MYCOTAXON

Volume XLII, pp. 297-306 October-December 1991

PURE CULTURE STUDIES ON VOLUCRISPORA GRAMINEA AND ISTHMOTRICLADIA BRITANNICA (HYPHOMYCETES)

by

A. ROLDAN

Centro de Edafología y Biología Aplicada del Segura - CSIC. PO Box 4195. Murcia. Spain.

Summary: *Volucrispora graminea* Ingold, Mc Dougall & Dann and *Isthmotricladia britannica* Descals have been repeatedly isolated in pure culture from Spanish streams. Re-examination of these isolates has provided additional information and, after comparing with the original descriptions, an extension of their species concepts of both taxa is proposed.

INTRODUCTION

Most aquatic hyphomycetes have been described in pure cultures derived from conidia in foam samples. These usually come from a single locality and lack a representative range of the variability of the species. In the course of an extended survey of aquatic hyphomycetes in Spain, several isolates of *Volucrispora graminea* Ingold, Mc Dougall & Dann and *Isthmotricladia britannica* Descals were obtained from different habitats and sites. Examination of these isolates has provided some additional information regarding morphology and ecology. The specific concept of both fungi is extended in this paper.

METHODS

Techniques used for isolation, pure culture and sporulation are basically those detailed in Descals *et al* (1977) and in Webster & Descals (1981), except with regard to temperature (14-18 °C) and photoperiod (normal daylength) of incubation for colony characteres and sporulation induction.

Collections numbers preceded by "MUB AR" refer to specimens kept in the herbarium of the author, presently housed in the Botany Department of the University of Murcia (Spain).

Volucrispora graminea Ingold, Mc Dougall & Dann
(based on our isolates)

Colony on malt agar (MA) typically white to pale cream, glabrous, growth moderate, reaching 3.7 cm diam in one month; aerial mycelium absent. **Sporulation** nil with or without submersion of colony slices in sterile, distilled standing water, but very abundant when aerated non-axenically for 3 days at room temperature. **Conidiophores** semimacronematous, apical (or lateral), simple or loosely branched, stalk 30-70 X 1.5-2 µm. **Conidiogenous cells** apical (seldom intercalary or lateral), solitary; when apical slightly clavate, polyblastic, sympodial, 13-32 X 2.5-3 µm. **Conidia** acrogenous (seldom pleurogenous), staurosporous; when acrogenous in loose fascicles of up to 4 conidia; when pleurogenous solitary. Mature conidia consistig of a slightly curved or somewhat sinuate main axis (seldom straight), 22-75 X 1.5-2 µm, up to 3-septate, apex acuminate and basal scar truncate, sometimes with a short basal extension. Branches 1-(2), pleurogenous and sequential, arranged in one order and arising mostly inmediately below septa, and slightly constricted at the insertion, with or without basal septa, antrorse, mostly diverging in one plane, 6-22 X 1-2 µm. Conidia secede schizolytically and germinate readily in liquefied foam or on agar with antibiotics.

Collections: monoconidial isolates from foam in Rio Cuervo, Cuenca: MUB AR 9812; MUB AR 9845 (Roldán, Dec. 1987). Monoconidial isolate from submerged *Populus* wood test-blocks in Rio Vinalopó, Bañeres (Alicante): MUB AR 9857 (Roldán, March 1988).

This species is widely distributed over a range of climates. The fungus appears to be associated with the decomposition of allochtonous organic matter in freshwater habitats, although it also has been reported from terrestrial ones (Webster & Descals, 1981). As far as we know *Volucrispora graminea* has always been reported from foam or grasses, so it is remarkable that it has now been isolated from submerged wood in both lotic and lentic habitats (Roldán et al , 1989). It had also been reported from leaves of *Populus alba* and *Salix atrocinerea* at the same locality (Roldán, 1988). Other records in Spain are those of Descals *et al* (1978), Descals (1987, as *Tricellula graminea*) and Roldán *et al* (1987 a, b).

Volucrispora graminea was first isolated from *Dactylis glomerata* (Webster, 1954), who did not publish his fungus although he was aware of its novelty. Ingold, Mc Dougall & Dann (1968) formally described the fungus with an isolate from foam. In spite of Webster's proposal of a new genus for the fungus (*Upsylon*), Ingold *et al* (op. cit.) classified it in *Volucrispora* Haskins (1958) because of conidial formation at intervals along hyphae forming dense clusters with up to 30 spores, all budded from around the blunt apex of the same short lateral branch.

Although the holotype has not been seen, an authenticated specimen was examined (Descals B107-3-3). As shown on figs. 2 and 3, conidiogenesis in this isolate is predominantly lateral, conidiogenous cells are intercalary and polyblastic with denticulate scars; dense clusters of spores were observed, not only around a blunt apex of a short lateral branch but mostly on a recurved branching system. Conidia are structurally identical with those of our isolates but, when two lateral branches are present they appear opposite at the same level on the main axis. Conidial dimensions in authenticated material (23-50 X 1.5-3 μm) clearly overlaps with those of Spanish isolates.

Some features distinguish our Spanish isolates from the traditional *V. graminea* species concept: 1- Spanish isolates derive from foam or submerged wood, the fungus has also been recorded here from deciduous leaves; 2- conidiogenesis in our Spanish isolates is predominantly apical with conidiogenous cells proliferating sympodially, while in the protologue conidiogenesis is lateral and conidiogenous cells are solitary and do not proliferate; 3- conidia in our isolates sometimes display two arms arranged at different levels, but in the original description a single branch is mentioned. However other features i.e. colony characteristics and conidial morphology in nature have been considered more diagnostic, and suggest the conspecificity of our Spanish isolates with *V. graminea.* Moreover substratum differences are not relevant enough bearing in mind the general lack of knowledge on the ecology of aquatic hyphomycetes. Variations in conidiogenesis and conidiogenous apparatus cannot be weighted because the authenticated material examined is intermediate between our isolates and the protologue; finally the different ramification patterns of conidia can be attributed to sporulation conditions (forced aeration in our case) or intraspecific variability of this taxon.

From the above it may be convenient to widen the specific concept of *Volucrispora graminea*.

With regard to the classification of *V. graminea* it is evident that this species do not fit in *Volucrispora* Haskins. Descals (*in litt.*) pointed out the possibility of creating a new genus (*Upsylon*), as was first proposed by Webster. *Lambdasporium* Matsushima (1971) has a remarkably similar conidial shape. Nawawi (1985) mentioned the resemblance between his *Lambdasporium viridense* and *Volucrispora graminea*. This is more accused if we consider our Spanish isolates of *V. graminea*, although they differs in the degree of conidiophore branching and in colony pigmentation (blue-green to glaucous in *L. viridense*). *Lambdasporium* species are probably most similar to *Volucrispora graminea* and identification of single conidia (often done in ecological studies) may be problematic.

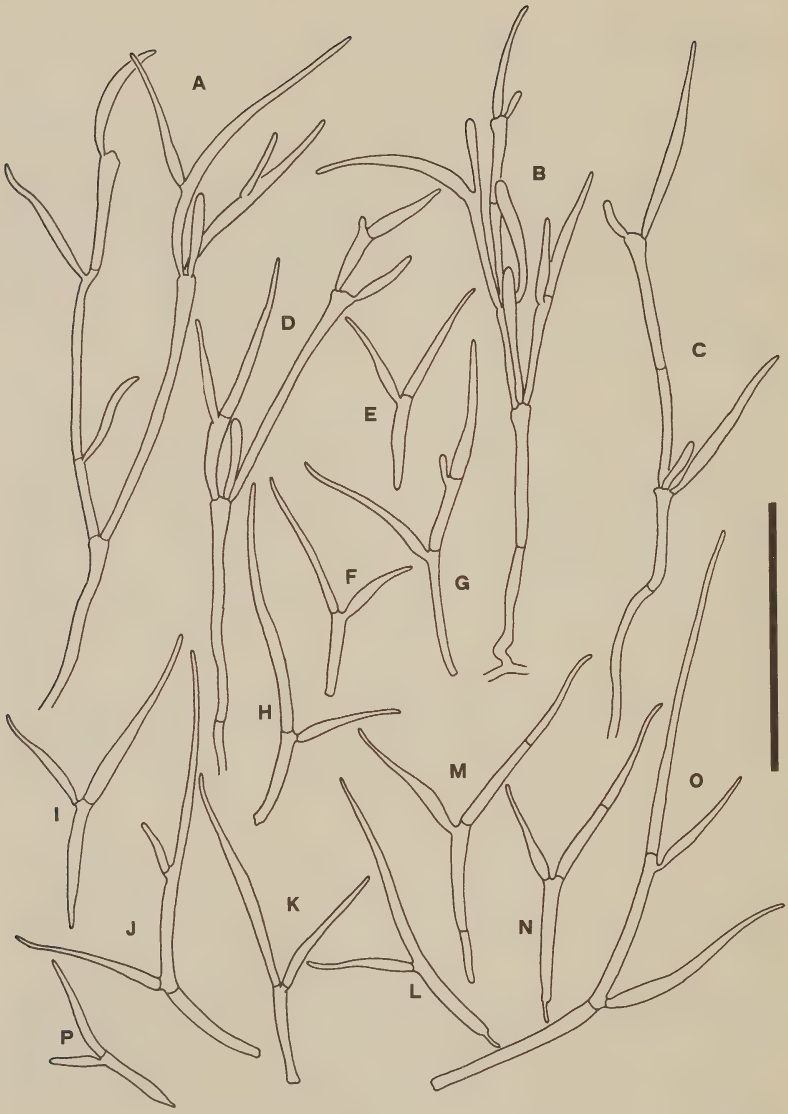

A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P

Fig. 1.- *Volucrispora graminea* (isolate MUB AR 9857). A-D conidiophores, notice sympodial proliferations. E-P detached conidia. Bar = 50 µm

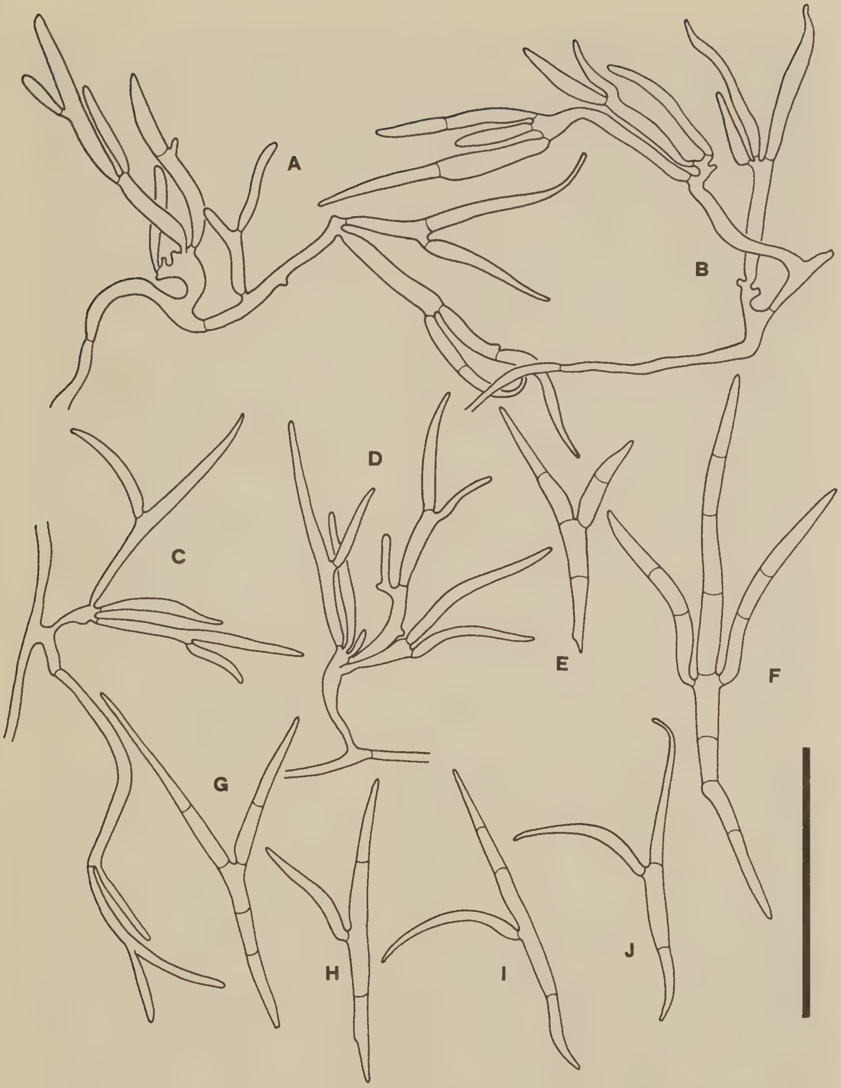


Fig. 2.- *Volucrispora graminea* (Herb. Descals, isolate B107-3-3, authenticated). A-D conidiophores (notice denticulate scars on conidiogenous cells). E-J detached conidia. Bar = 30 µm.

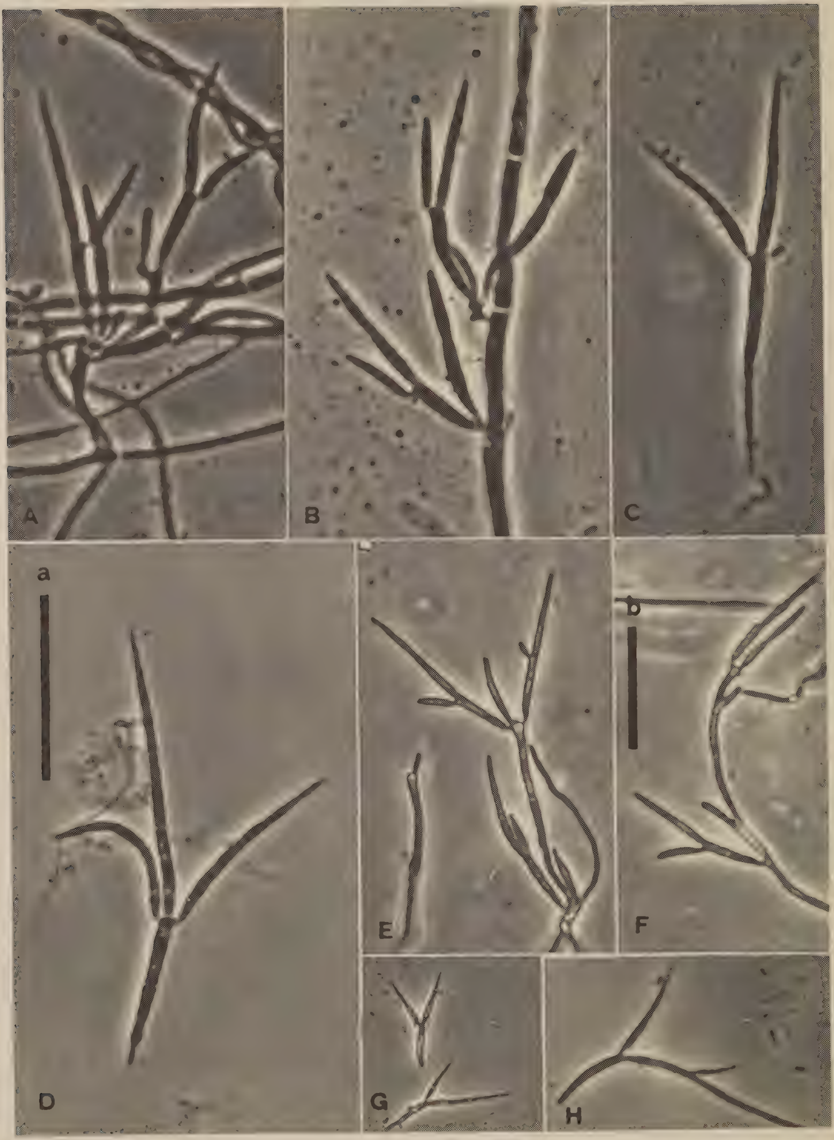


Fig. 3.- *Volucrispora graminea* in culture (lactofuchsin mounts). A-D: from Descals B107-3-3, bar "a" = 20 µm. E-H from AR 9812, bar "b" = 20 µm

Isthmotricladia britannica Descals

Colony on malt agar (MA) typically pale greyish orange (seldom pink), surface radially convoluted, growing moderately slow, reaching 2.7 cm diam in one month; aerial mycelium absent. **Sporulation** failed, but was very abundant on slices of culture partly submerged in sterile, distilled standing water for 4 days at room temperature, at or below water level. **Conidiophores** micronematous, seldom semimacronematous, and then disposed loosely or aggregated. **Conidiogenous cells** solitary, integrated, apical or lateral, polyblastic sympodial, often rachiform, 8-26 X 1.5-2.5 µm. **Conidia** solitary, acrogenous, staurosporous, with a basal element straight to slightly sinuous, cylindric to clavate, 14-32 X 1.5-3.5 µm, up to 4-septate; base truncate, in some isolates with a short percurrent extension. Branches typically 3 to 5, coronate, synchronous, antrorse at variable angles through 90°, straight to slightly sinuous, fusoid to clavate, 25-50 X 1.5-3.5 µm, up to 4-septate, apex mostly acuminate in various degrees. Mature conidia secede schizolytically and germinate readily in liquefied foam or on agar with antibiotics, a single germ tube being formed on each conidial element.

Collections: monoconidial isolates from foam in Campamento San Juan, Riópar (Albacete): MUB AR 9769; MUB AR 9770; MUB AR 9784; MUB AR 9792(Roldán, Nov. 1987). Cañada de los Mojones, Riópar (Albacete): MUB AR 9785.

Conidia with similar shape to those of *Isthmotricladia britannica* Descals are relatively frequent in foam samples from Spain, but because of its great variability and in absence of pure culture they have not been named, i.e. Roldán & Honrubia (1990, Figs 8I and 9K) and Descals & García-Manjón (1989, figs 2F and 7C). It is relevant that we have never recorded this fungus from natural substrata, usually occurring in foam samples just after rains.

The isolates here described fit well into *I. britannica* but cover a wider range of variability than the original description. Colony pigmentation is typically pale greyish orange in the Spanish isolates (pale greyish brown in the protologue, although our isolate AR 9785 is pale pink). Conidiophores in the isolates here described are micro- to semimacronematous, sometimes sporodochial, while in the protologue they are micronematous. Conidial dimensions clearly overlap with those of the holotype but some isolates present significant differences in conidial morphology: AR 9769 display conidia with 4 to 5 coronate elements (4 in the protologue) with a less acute apex (AR 9769 and AR 9792 are from conidia isolated from foam with 8 and 7 arms respectively) and widely divergent; in isolate AR 9785 conidial branches are obclavate (fusoid in the holotype) and the basal scar is usually replaced by a short percurrent extension.

Descals (1982) differentiated his *I. britannica* from *I. laeensis* Matsushima (1971), the type species, on the basis of the number and orientation of the conidial arms, typically 4 in *I. britannica*, and diverging at a narrow angle, whereas in *I. laeensis* they are typically 3 and broadly divergent. Some isolates described here, such as AR 9874, present 3 to 4 conidial arms and these diverge variously. It seems possible that we are dealing with a highly polymorphic species but more cultures from the type localities must be obtained to clearly delimit these two taxa.

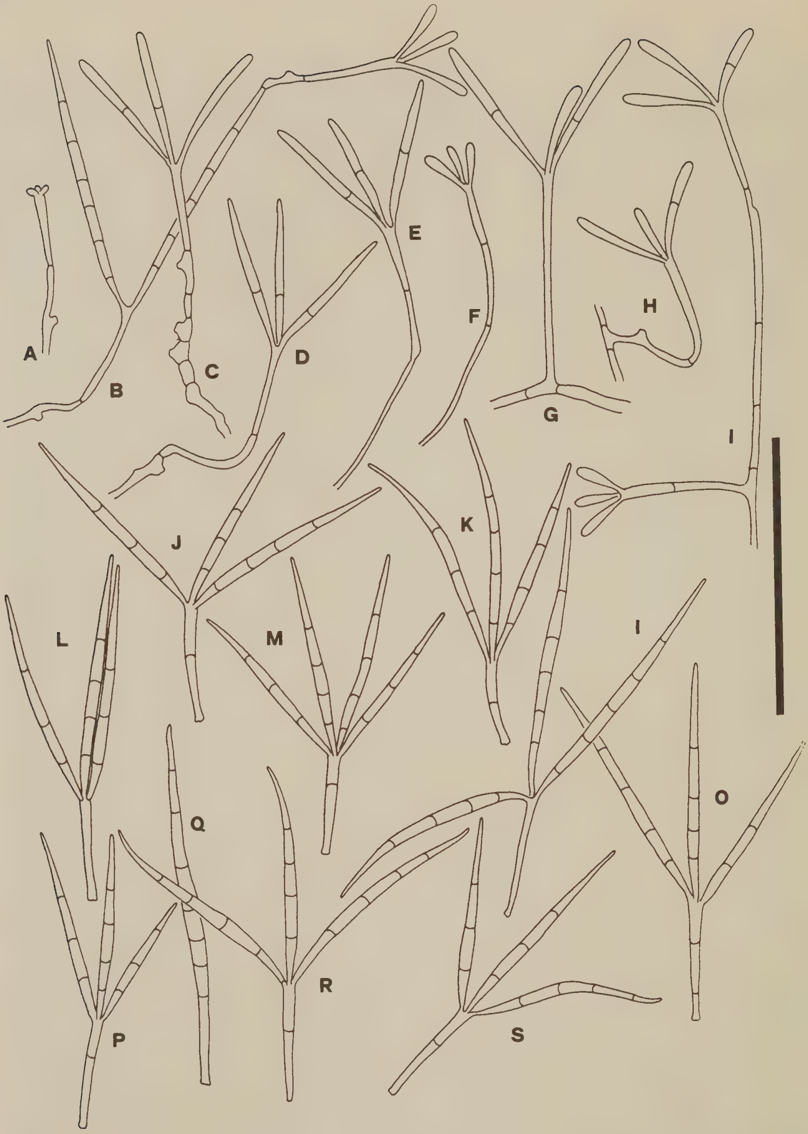

A
B
C
D
E
F
G
H
I
J
K
L
M
I
O
Q
R
P
S

Fig. 4.- *Isthmotricladia britannica* (isolate AR 9784). A-F micronematous conidiophores. J-S detached conidia (most conidia with 3 variously divergent arms). Bar = 50 µm.

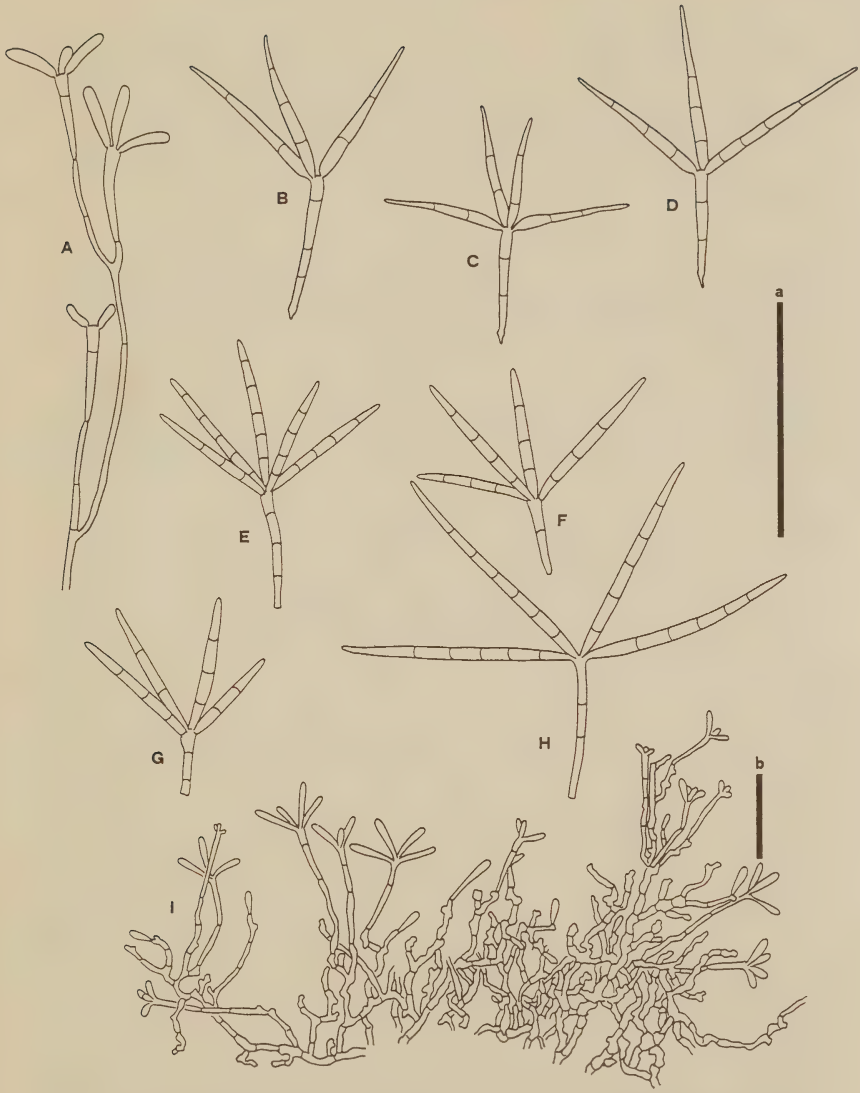


Fig. 5.- *Isthmotricladia britannica* in pure culture. A-D from isolate AR 9785, notice semimacronematous conidiophores in A and detached conidia with clavate arms and short basal extension in B, C and D. E-I from isolate AR 9769, notice densely aggregated conidiophores (I) and detached conidia with 4 to 5 variously divergent arms. A-H: bar "a" = 50 µm; I: bar "b" = 40 µm.

ACKNOWLEDGEMENTS

We are indebted to Dr E. Descals for kindly providing authenticated *Volucrispora graminea* specimens and for correcting this manuscript.

REFERENCES

DESCALS, E. & GARCIA-MANJON, J.L. (1989). Hongos acuáticos ingoldianos en la Sierra de Guadarrama. *Bol. Soc. Micol. Madrid*, 13:11-26.
DESCALS, E. & WEBSTER, J. (1982). Taxonomic studies on aquatic hyphomycetes. III. Some new species and a new combination. *Trans. Br. mycol. Soc.*, 78:405-437.
DESCALS, E.; SANDERS, P.F. & UGALDE, U.O. (1978). Hifomicetos ingoldianos del País Vasco. *Munibe*, 29:237-260.
DESCALS, E.; WEBSTER, J. & DYKO, B.J. (1977). Taxonomic studies on aquatic hyphomycetes. I. *Lemonniera* De Wildeman. *Trans. Br. mycol. Soc.*, 67:89-109.
HASKINS, R.H. (1958). Hyphomycetous fungi: *Volucrispora aurantiaca* n. gen. n. sp., *V. ornithomorpha* (Trotter) n. comb., *Tricellula curvatis* n. sp., with the genus *Tricellula* emmended. *Can. J. Microbiol.*, 4:273-285.
INGOLD, C.T.; Mc DOUGALL, P.J. & DANN, V. (1968). *Volucrispora graminea* sp. nov. *Trans. Br. mycol. Soc.*, 51:325-328.
MATSUSHIMA, K. (1971). Mycological reports from New Guinea and the Solomon Islands. 7. Some interesting Fungi Imperfecti. *Bull. Nat. Sc. Museum, Tokyo*, 14:460-480.
NAWAWI, A. (1985). Some interesting fungi from water. *Mycotaxon*, 24:217-226.
ROLDAN, A. & HONRUBIA, M. (1990). Catálogo provisional de los deuteromicetos acuáticos de la provincia de Alicante. *Bol. Soc. Micol. Madrid*, 14:21-42.
ROLDAN, A. (1988). *Deuteromicetos acuáticos: taxonomía y ecología en cursos mediterráneos.* Univ. Murcia, Doctoral Dissert.
ROLDAN, A.; DESCALS, E. & HONRUBIA, M. (1987 a). Hifomicetos acuáticos en la Serranía de Cuenca. *Bol. Soc. Micol. Madrid*, 11:179-184.
ROLDAN, A.; DESCALS, E. & HONRUBIA, M. (1987 b). Hifomicetos acuáticos en las cuencas altas de los ríos Segura y Guadalquivir. *Anals. Biol. Univ. Murcia*, 13:3-13.
ROLDAN, A.; PUIG, M.A. & HONRUBIA, M. (1989). Comunidades fúngicas asociadas a sustratos leñosos en un río mediterráneo. *Annls. Limnol.*, 25(3):191-195.
WEBSTER, J. & DESCALS, E. (1981). Morphology, distribution and ecology of conidial fungi in freshwater habitats. In: Cole, G.T. & Kendrick, B. (Eds.). *The Biology of Conidial Fungi.* Vol I. Academic Press:295-355.
WEBSTER, J. (1954). *The micro-fungi of Dactylis glomerata.* Ph.D. Dissert. Univ. London.

MYCOTAXON

Volume XLII, pp. 307-317 October-December 1991

STUDIES IN THE GENUS CLADOSPORIUM SENSU LATO. V. CONCERNING THE TYPE SPECIES, CLADOSPORIUM HERBARUM

JOHN M. MCKEMY and GARETH MORGAN-JONES

Department of Plant Pathology, College of Agriculture and Alabama
Agricultural Experiment Station, Auburn University, Auburn, Alabama 36849

ABSTRACT

The type species of *Cladosporium* Link, *C. herbarum* (Pers.) Link, an ubiquitous fungus on a variety of different hosts, decaying plant material and other substrates is redescribed and illustrated. Its salient features from nature and *in vitro* are documented.

INTRODUCTION

The genus *Cladosporium* Link was established during the early part of the last century (Link, 1815) and contained four original species; namely, *C. herbarum* (Pers.) Link, *C. abietinum* (Pers.) Link, *C. aureum* Link and *C. atrum* Link. In a subsequent publication, Link (1824) made mention of three of these species, but not *C. aureum*. *Cladosporium herbarum* and *C. abietinum* had initially been named as species of *Dematium* Persoon [as *D. herbarum* Pers. and *D. abietinum* Pers., respectively (Persoon, 1794, 1801)]. This generic name is now considered a *nomen confusum* (see Carmichael *et al*., 1980) and some of its species are currently classified in such unrelated genera as *Helminthosporium* Link and *Periconia* Tode, as well as *Cladosporium* (see Hughes, 1958). *Cladosporium herbarum*, being the first species listed by Link, was, over the years [see, for example, Clements and Shear (1931)], regarded as the type species of *Cladosporium*. This practice was followed by de Vries (1952) in his revision of the genus and by Hughes (1958), who formally designated *C. herbarum* as lectotype species. *Dematium abietinum* was considered to be an alga, and *C. atrum* reported as mycelia sterilia, by Hughes (1958), while the status of *C. aureum* was not noted and remains, to our knowledge, undetermined. Another of Persoon's original species of *Dematium* (Persoon, 1801), *D. epiphyllum* Pers., and three species described in this genus by him subsequently (Persoon, 1822), namely *D. fuscum* Pers., *D. graminum* Pers., and *D. vulgare* Pers., δ *typharum* Pers., were listed by Hughes (loc. cit.) as facultative synonyms of *C. herbarum*.

Alabama Agricultural Experiment Station Journal Series No. 18-913026

When Link (1815) established *Cladosporium* he gave the genus the following description: "Thallus e floccis caespitosis erectis simplicibus aut subramosis, apicibus in sporidia secedentibus. A *Sporotricho* et *Oidio* differt floccis non intricatis, ab Acladio sporiidis apici primum innatis, dein delabentibus". *Dematium herbarum* was first reported by Persoon (1794) from rotten wood. Persoon (1801) described this species as being "effusum compactum virescente-olivaceum pulverulentum. In caulibus plantarum maiorum, colore laeto olivaceo distinguitur," while Link (1815) reported it to be "atrovirens, densum, effusum, floccis septatis, syn.: *Acladium herbarum* Berl. Mag. p. 10. *Dematium herbarum* Pers.". Link (1809) had, in fact, previously reclassified *D. herbarum* as *Acladium herbarum* (Pers.) Link.

In Fries' (1832) treatment of *Cladosporium*, eight species were described in the genus, but only two of those originally included by Link, *C. herbarum* and *C. atrum*. Persoon's *Dematium epiphyllum* (as *Cladosporium epiphyllum* [*C. epiphyllum* (Pers.) Nees]) and *Dematium fuscum* (as *C. fuscum*) were included, but his *D. graminum* was retained in *Dematium*, with the name *Cladosporium graminum* [*C. graminum* (Pers.) Link] noted as a synonym. Hughes (loc. cit.) listed *Cladosporium fuscatum* Link [*Linn. Spec. Plant.*, IV, 6(1): 41, 1824] as a synonym of *D. fuscum* [i.e. *C. herbarum*], while *Cladosporium fuscum* Link [*Linn. Spec. Plant.*, IV, 6(1): 40, 1824] was considered to be a basidiomycete. Additional species included by Fries (loc. cit.) were *Cladosporium fasciculare* Fr., *C. fumago* Link [*Linn. Spec. Plant.*, IV, 6(1): 41, 1824], *C. smilacis* (Schw.) Fr. [≡ *Dematium smilacis* Schw.], and *C. umbrinum* Fr. The binomial *Dematium articulatum* Pers. [*Syn. Meth. Fung.* 694, 1801] was listed as a synonym of *C. fasciculare*. Hughes (loc. cit.) cited *D. articulatum* and *C. fasciculare*, among others, as synonyms of *Coelosporium fruticulosum* Link, the type species of *Coelosporium* Link, a generic name now regarded as a *nomen dubium* (see Carmichael *et al.*, 1980). This synonymy was noted by Hughes to be bibliographically derived, since he had not examined authentic material of *D. articulatum*. Saccardo (1884) listed *C. fumago* as being conspecific with *Fumago vagans* Pers. [*Mycol. Europ.* 1: 9, 1822], the lectotype species of *Fumago* Pers. (Hughes, loc. cit.). Friend (1965) concluded that *F. vagans* was based on a mixture of *Aureobasidium pullulans* (de Bary) Arnaud and *C. herbarum* and that, because of this, the generic name *Fumago* should be rejected. Hughes (1976) concurred with this finding.

Corda (1837) classified fifteen species in *Cladosporium*, only one of which had been included by Fries. Of these, six were listed by Hughes (1958) as facultative synonyms of *C. herbarum*. Many other binomials published thereafter are also considered to be synonyms of *C. herbarum* [see Hughes (1958)]. Addition of further species to the genus, by many authors, has proceeded more or less unabated during the ensuing century and a half with the result that more than five hundred taxa have, to date, been classified in the genus (Prasil and de Hoog, 1988; Morgan-Jones and McKemy, 1990). Currently, as indicated elsewhere (Morgan-Jones and McKemy, loc. cit.), the status of the vast majority of these is uncertain.

De Vries (1952), in his revision of *Cladosporium*, considered the typification of *C. herbarum* and chose a collection in Link's herbarium (B), made on dead stems of *Malva mauritanica* Spreng. at Karlsruhe in 1846, as lectotype. De Vries (loc. cit.) reported the presence of three specimens labelled *Dematium herbarum* in Persoon's herbarium at Leiden (L). Of these, one [910.255-730], bearing a question mark after the name, was determined to be *Cladosporium cladosporioides* (Fres.) de Vries [≡ *Penicillium cladosporioides* Fres., *Beitr. zur Mykol.* 22, 1863]. Another [910.255-731] was found not to be a *Cladosporium*, while the third [910.255-733] was said to be in poor condition, with two-celled conidia and broken conidiophores present. In choosing Link's specimen as lectotype, as pointed out by Prasil and de Hoog (loc. cit.), de Vries (1952) took action contrary to the rules and recommendations contained in Article 7 of the International Code of Botanical Nomenclature. Since an authentic specimen, though scanty, of *D. herbarum* is extant in Persoon's herbarium, this should be designated as lectotype for the name. Accordingly, Prasil and de Hoog (loc. cit.) chose specimen 910.255-733 to serve this purpose. A living isolate [CBS 177.71], maintained at the Centraalbureau voor Schimmelcultures, Baarn, which matches this specimen was also selected by Prasil and de Hoog (loc. cit.) as a representative strain.

Ellis (1971) reported *C. herbarum* to be a common species, of widespread distribution, on dead herbaceous and woody plants, especially in temperate climates, and to also occur in soil, and on foodstuffs, paint and textiles. Extensive records of its occurrence in soil and information on its biology were compiled by Domsch *et al.* (1980). Farr *et al.* (1989) reported the fungus to occur on upwards of ninety host plant genera in the United States and to be implicated in a variety of disorders as well as occurring as a secondary invader and saprophyte. Some of the conditions with which *C. herbarum* has been associated include black mold of peanut [*Arachis hypogaea* L.] pods, velvet mold and fruit spot of *Capsicum* spp., fruit spot of common fig [*Ficus carica* L.], black root, secondary leaf and fruit rot of strawberry [*Fragaria* X *ananassa* Duchesne; *F. chiloensis* (L.) Duchesne], boll rot of cotton [*Gossypium hirsutum* L.], blossom rot of tobacco [*Nicotiana tabacum* L.], and pod and seed spot of *Phaseolus* spp. *Cladosporium herbarum* also occurs as a black mold associated with scale insect infestation.

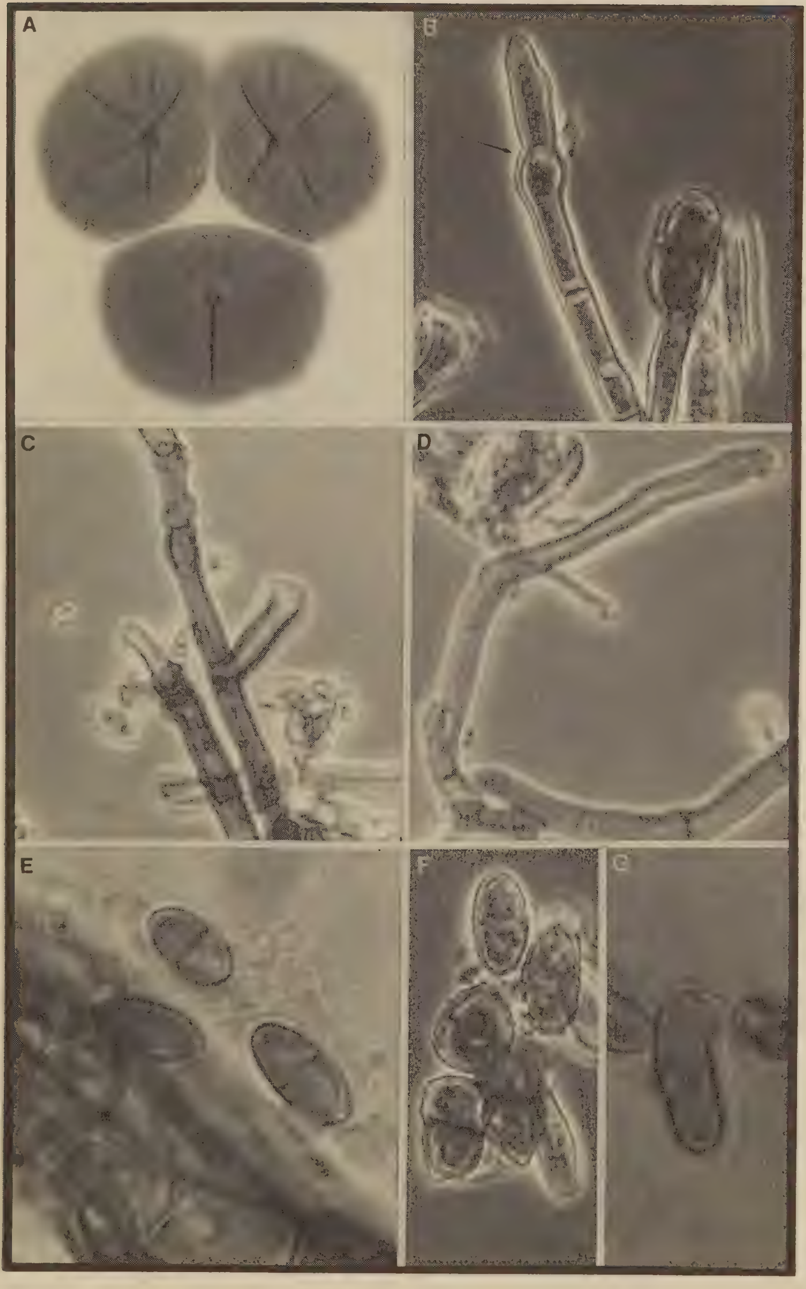
Cladosporium herbarum has been reported to be the anamorph of *Mycosphaerella tassiana* (de Not.) Johans., (von Arx, 1949, 1950, 1983; Barr, 1958; Corlett, 1988). In von Arx's studies, the anamorph was obtained *in vitro* in cultures derived from single ascospores. The teleomorph and anamorph appear to be infrequently associated in nature, and von Arx (1949) suggested that either one of the propagative states may be absent, depending upon climatic conditions. A cold climate was thought to favor teleomorph development, whereas the anamorph predominates in warm conditions. In collections of *M. tassiana* reported on members of the Brassicaceae from Canada, the anamorph was rarely encountered (Corlett, 1988). Ruehle (1930) and Subramanian (1971) reported *C. herbarum* to be the anamorph of *Mycosphaerella tulasnei* (Jancz.) Lindau, but von Arx (1950) considered this name to be a synonym of *M. tassiana.* Prasil and de Hoog (1988) found the evidence for the teleomorph/anamorph connection discussed above to be inconclusive. They reported the five isolates of *M. tassiana* maintained in the Centralbureau voor Schimmelcultures, including von Arx's original anamorph and teleomorph strains, to be variable both culturally and morphologically, and to differ significantly from *C. herbarum* in the sense of their selected representative isolate [noted above].

De Vries (1952) reported on an isolate determined to be *Cladosporium macrocarpum* Preuss, maintained at the Centralbureau voor Schimmelcultures under the name *Mycosphaerella tulasnei*, and originating from ascospores, and found it to be different from von Arx's isolates of *M. tassiana*. He maintained that *C. macrocarpum* differs from *C. herbarum* by possession of larger, more regularly verrucose conidia, shorter conidial chains, more pronounced prolongations of the conidiophores and a tendency to produce crustose stromata on agar. Ellis (1971) stated that *C. macrocarpum* is allied to *C. herbarum* but can be distinguished from it by its broader frequently 2- and 3-septate conidia. Subsequent authors, such as Domsch *et al.* (1980), von Arx (1983), Matsushima (1985), and Farr *et al.*, (1989), have also maintained *C. macrocarpum* as a separate species. Barr (1958), however, found the anamorph of *M. tassiana* to be quite variable and that different isolates may be considered either *C. herbarum* or *C. macrocarpum*. Corlett (1988) reported one collection of *M. tassiana* from Canada in which the teleomorph was associated with an anamorph which he considered as being closer to *C. macrocarpum* than *C. herbarum* and further stated that the two anamorph species intergrade. If the two are determined to be conspecific, the earlier name, *C. herbarum*, would have priority.

A number of authors, such as de Vries (1952), Ellis (1971), Subramanian (1971), Domsch *et al.* (1980) and Matsushima (1985) have provided variously detailed treatments of *C. herbarum*, and there are literally thousands of records of it in the literature, but no modern, fully comprehensive account of its characteristics *in vivo* and *in vitro* has been published. Hashmi *et al.* (1973) described conidiogenesis and Prasil and de Hoog (1988) gave account of its variability in culture with emphasis on conidiophore morphology. The latter authors also evaluated the status of twenty three infraspecific taxa, at varietal and forma level, previously described in *C. herbarum*. Fourteen of these were determined to be of doubtful identity and nine to be identical to the species and not worthy of separate taxonomic recognition. Colony growth was described in detail and two types of conidiophore growth patterns recognized, reflected in primary and secondary colony layers.

Cladosporium herbarum occurs frequently in the southeastern United States on cereals and grasses, where it is associated with so-called glume or black head mold and leaf mold symptoms. Where present, the inflorescence and leaves of colonized plants are appreciably discolored. During the course of our studies on *Cladosporium*, we have examined a number of specimens on barley,

PLATE 1. *Cladosporium herbarum*. A, 14-day-old colony on PDA; B, conidiophore from nature showing swollen node and lateral scar (arrow); C, conidiophore showing branching and conidia; D, typical conidiophore sympodial growth; E-F, smooth and verruculose conidia; G, ramo-conidium.


A
B
C
D
E
F
G

oat and wheat and have isolated the fungus in pure culture. In addition, we have had opportunity to examine a number of herbarium specimens originating elsewhere. As a contribution to our understanding of this species, a detailed account of its characteristics in culture and *in vivo* is offered herein.

TAXONOMIC PART

Cladosporium herbarum (Pers.) Link, *Mag. Ges. naturf. Freunde, Berlin* 7: 37, 1815 (Figure 1, Plate 1).

≡ *Dematium herbarum* Pers., *Usteri's Ann. Bot.*, 11 *Stuck* 32: 1794.

(For additional synonyms, see Hughes, 1958.)

Colonies in nature effuse, dull olive to dark olivaceous black, velvety, often forming extensive, sometimes irregular, blackish areas over the host surface, particularly if stromata are present. Mycelium superficial or immersed in the host tissue, composed of branched, septate, smooth, subhyaline to pale brown, 3-4 µm wide, hyphae. Where superficial, sometimes forming a repent network on the host surface. Stromata often well-developed, composed of tightly-packed clusters of more or less isodiametric, mostly subglobose, thick-walled, pale brown to brown, 7-10 µm wide cells, usually forming flat, irregular, plate-like masses close to the host surface, rarely somewhat pulvinate. Individual or chains of similar, inflated, chlamydospore-like cells often present along the length of superficial hyphae but not aggregated into stromata. Colonies on potato dextrose agar (PDA) [Difco] grown at 25C attaining a diameter of 30 and 61 mm after 7 and 14 days, respectively. After 7 days, colonies lanose over the entire surface, sulcate with radial furrows extending from the center outward various distances, coloration varying from Dark Green [29F5] to Dull Green [29E3] at the extreme periphery (Kornerup and Wanscher, 1978), margin even. Colony reverse evenly Bronze Green [30F3] with radial furrows visible. Colonies on PDA at 20C and 30C attaining a diameter of 32 mm and 9 mm after 7 days, respectively; appearance and coloration at 20C similar to those at 25C; at 30C, colonies markedly convoluted. Conidiophores in nature macronematous, mononematous, solitary or, more frequently, in caespitose clusters, robust, erect, straight, rigid to slightly flexuous, becoming markedly geniculate in apical, fertile portion following sympodial growth associated with serial conidiation, smooth, cylindrical, thick-walled, cicatrized, with scars relatively prominent, septate, occasionally branched, sometimes nodose, mid to pale-brown, bulbous at the base, up to 300 µm long X 4-8 µm wide, up to 9 µm wide at the intercalary swellings, 6-10 (12) µm wide at the base. In culture, conidiophores macronematous or semi-macronematous, mononematous, mostly flexuous, more slender than in nature and generally thinner-walled, pale-olive green to light brown, up to 700 µm long X 3-5 µm wide, arising as lateral branches from repent hyphae or terminally from ascending hyphae. Conidiogenous cells holoblastic, polyblastic, integrated, terminal or intercalary, intermittently determinate, often appreciably bent as a result of sequential, sympodial growth. Conidia in nature in long, branched chains. Ramo-conidia cylindrical to clavate, ampulliform, sometimes slightly curved, ranging from

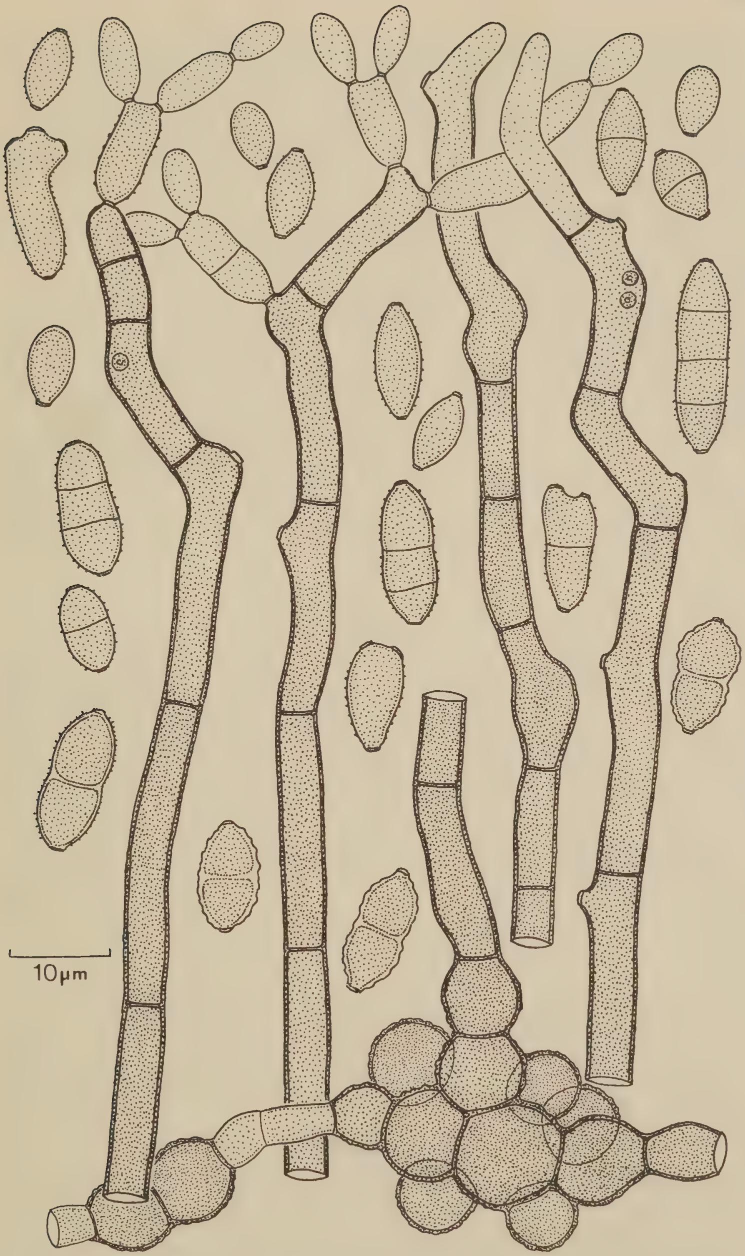


FIGURE 1. *Cladosporium herbarum.* Stromata, condiophores and conidia from nature.

smooth to verruculose, 0-4 septate, cicatrized, mid to pale olivaceous green, 6-36 X 4-8 µm, mostly 12-20 µm long; in culture, paler in color, 0-2 septate, up to 45 µm long, mostly 10-20 X 3-6 µm. Intercalary conidia ellipsoidal to limoniform, oblong or fusiform, pale olive brown, smooth to verruculose, 0-1 septate, up to 25 µm long, 4-8 µm wide; in culture 0-1 septate, up to 20 um long, 4-6 µm wide. Terminal conidia subglobose to oblong, 4-8 µm.

On herbaceous and woody plants, in soil, and on man-made substrates; cosmopolitan.

Collections examined: on culm of *Bambusa* sp., Yangso, Kwangsi, China, S.C. Teng, March 2, 1933, BPI 427412, AUA; on leaf of *Altheae rosea* L., Kew, Surrey, U.K., August 16, 1960, F.C. Deighton, IMI 82081 (a), AUA; on leaf of *Acer pseudoplatanus* L., Slapton Ley, S. Devon, U.K., August 31, 1972, D.L. Hawksworth and P.W. James, IMI 168652, AUA; on *Avena* sp., Auburn, Lee Co., Alabama, May 13, 1990, G. Canullo, AUA; on inflorescence of *Triticum aestivum* L., Auburn, Lee Co., Alabama, U.S.A., G. Canullo, May 13, 1990, AUA, and isolate derived from this [deposited at ATCC]; on inflorescence of X *Triticosecale*, Auburn, Lee Co., Alabama, U.S.A., G. Canullo, May 13, 1990, AUA; on inflorescence of *Hordeum vulgare* L., Auburn, Lee Co., Alabama, U.S.A., G. Canullo, May 13, 1990, AUA.

DISCUSSION

The morphology of *C. herbarum*, like that of many other species of *Cladosporium*, varies somewhat depending upon growth conditions, both *in vivo* and *in vitro*. Appreciable differences in conidiophore morphology exist between those found in nature and those produced *in vitro* on agar media. *In vivo*, conidiophores, which frequently originate from chlamydospore-like, thick-walled cells, are shorter, more robust, pigmented and septate, and thicker-walled than in culture. In nature, an intermittently determinate conidiophore growth pattern occasionally occurs where terminal, apical growth ceases and, following a period during which one to several ramo-conidia are formed at the apex, is renewed sympodially. Where a pause in apical growth occurs in this manner, the conidiophore apex tends to swell somewhat and the inflated portion remains following renewed growth, giving the conidiophore a nodose appearance. Sympodial growth and continued successive septation can be appreciable in *C. herbarum*, resulting in a number of condiogenous cells assuming an intercalary position. Consequently, conidiophores become geniculate, often with somewhat abrupt bending. In this regard, *C. herbarum* is rather distinctive. In culture, distinctively nodose conidiophores do not occur, or at least intercalary swellings are less pronounced than in nature, and sympodial growth tends to be more extensive [see also, Prasil and de Hoog, (1988)]. In regard to having intermittently determinate and, as a result, nodose conidiophores, *C. herbarum* resembles *C. colocasiae* Sawada and *C. oxysporum* Berk. & Curt. (see McKemy and Morgan-Jones, 1991). In those species, however, swollen nodes occur much more regularly along the length of the conidiophores and are usually more pronounced. This is especially the case in *C. colocasiae* (Bugnicourt, 1958; Ellis, 1971). These species are easily distinguished by their conidium morphology. Those of *C. colocasiae* and *C.*

oxysporum are invariably smooth. Neither of these species has conidiophores that become as geniculate as those of *C. herbarum.*

The phenomenon of having primary and secondary conidiophore layers in colonies of *C. herbarum*, as described by Prasil and de Hoog (1988), appears to be of common occurrence in the genus *Cladosporium.* Different conidiophore layers were also noted to occur in *C. chlorocephalum* (Fres.) Mason & M.B. Ellis and in *C. tenuissimum* Cooke. Young colonies tend to have an even, velvety surface resulting from the development of conidiophores of more or less uniform length as erect, lateral branches from repent hyphae on or just below the agar surface. As colonies age, in some species, *C. herbarum* included, hyphal strands or ropes, made up of two or more intertwining hyphae, are formed giving the colony an uneven, sometimes funiculose appearance, particularly in the older, central portion. Coupled with this, continued apical, sympodial growth of ascending hyphae gives rise to a lanose overgrowth above the velvety, primary conidiophore layer. In some instances, several conidiophores may extend upwards, parallel-sided, and in close proximity to one another, creating a somewhat fasciculate aspect.

Within the genus *Cladosporium*, as presently constituted, three main types of conidiophore growth patterns are known. Recognition of these, and variations among them, is useful in better defining species concepts and in identification. The sympodial growth described above in *C. herbarum* is common in the genus, but a pronounced, geniculate conidiophore morphology is confined to relatively few species such as *C. geniculatum* Morgan-Jones. In some, such as *C. tenuissimum* Cooke, there is comparatively little increase in conidiophore length as successive conidiogenous loci are formed. Species of *Heterosporium* Klotzch, a genus which von Arx (1983) and McKemy and Morgan-Jones (1990) believe should be kept separate from *Cladosporium sensu stricto*, all have appreciable terminal, sympodial growth associated with conidiation. In comparison, in some species, such as the common *C. cladosporioides* and *C. sphaerospermum* Penz., there is little, if any, sympodial conidiophore growth, a large plurality of conidia being formed as a result of the formation of primary, secondary and tertiary ramo-conidia. A third type of conidiophore growth involves the formation of branches. *Cladosporium asterinae* Deighton, *C. breviramosum* Morgan-Jones and *C. musae* Mason, are examples of species bearing branched conidiophores.

Some variation in conidium ornamentation occurs in *C. herbarum.* Under certain conditions, such as when grown on corn meal agar [Difco], conidia are invariably verruculose. In nature and on PDA, conidia can be smooth or verruculose although the latter condition predominates, particularly in older conidia. Apart from conidiophore peculiarities, presence of conidium ornamentation is a useful way of distinguishing *C. herbarum* from some other common, ubiquitous species such as *C. cladosporioides*, and *C. tenuissimum.*

The question of the distinction between *C. herbarum* and *C. macrocarpum* remains open, as does that concerning whether or not *C. herbarum* is the anamorph of *Mycosphaerella tassiana.* Further detailed studies, both *in vivo* and particularly *in vitro*, are required before answers can be found. In our experience, assignment of the names *C. herbarum* and *C.*

macrocarpum to collections made in nature can be made with some confidence but we concede that a continuum might well exist between them. Once the question of the teleomorph/anamorph connection is satisfactorily resolved the proper application and status of these binomials will be easier to determine. There is little doubt that *M. tassiana* has an anamorph that is at least similar to *C. herbarum*. Whether or not it fully matches this fungus in the sense that it is understood by Prasil and de Hoog (1988) and described herein remains to be answered. It may well be that the anamorph of *M. tassiana* varies in the way that those of some other Ascomycetes, such as *Chaetosphaeria vermicularioides* (Sacc. & Roum.) W. Gams & Holubová-Jechová [anamorph *Chloridium virescens* (Pers.) W. Gams and Holubová-Jechová] (see Gams and Holubová-Jechová, 1976; Morgan-Jones *et al.*, 1991), do. In that case, it might well be useful to recognize the forms as varieties. The isolate from *T. aestivum* described above essentially matches the representative isolate studied by Prasil and de Hoog (loc. cit.). We do not find, however, the conidial scars on the conidiophores to be quite as dark as noted and illustrated by these authors.

ACKNOWLEDGMENTS

We thank Dr. J. Leland Crane, Illinois Natural History Survey, Urbana, for kindly reviewing the manuscript and making several valuable suggestions. Drs. Amy Y. Rossman, Systemic Botany and Mycology Laboratory, Beltsville, Maryland, and David L. Hawksworth, CAB International Mycological Institute, Kew, Surrey, United Kingdom, allowed us access to specimens housed in herbaria BPI and IMI, respectively, for which we are grateful.

LITERATURE CITED

BARR, M.E. 1958. Life history studies of *Mycosphaerella tassiana* and *M. typhae*. *Mycologia* 50: 501-513.

BUGNICOURT, F. 1958. Contribution a l'etude de *Cladosporium colocasiae* Sawada. *Rev. Mycol. Paris* 23: 233-236.

CARMICHAEL, J.W., W.B. KENDRICK, I.L. CONNERS and L. SIGLER. 1980. Genera of Hyphomycetes. The University of Alberta Press, 386 pp.

CLEMENTS, F.E. and C.L. SHEAR. 1931. The genera of fungi. Hafner, 494 pp.

CORDA, A.K.J. 1837. Icones fungorum hucusque cognitorum I. Prague. 32 pp.

CORLETT, M. 1988. Taxonomic studies in the genus *Mycosphaerella*. Some species of *Mycosphaerella* on Brassicaceae in Canada. *Mycotaxon* 31: 59-78.

DE VRIES, G.A. 1952. Contribution to the knowledge of the genus *Cladosporium* Link ex Fr. Diss. Univ. Utrecht, 121 pp.

DOMSCH, K.H., W. GAMS, and T.H. ANDERSON. 1980. Compendium of Soil Fungi. Vol 1. Academic Press, 859 pp.

ELLIS, M.B. 1971. Dematiaceous Hyphomycetes. Commonw. Mycol. Inst., 608 pp.

FARR, D.F., G.F. BILLS, G.P. CHAMURIS and A.Y. ROSSMAN. 1989. Fungi on plants and plant products in the United States. 1st Ed. APS Press, 1252 pp.

FRIEND, R.J. 1965. What is *Fumago vagans*. *Trans. Br. mycol. Soc.* 48: 371-375.

FRIES, E. 1832. Systema mycologicum 3(2). Greifswald, 261-524.

GAMS, W. and V. HOLUBOVA-JECHOVA. 1976. *Chloridium* and some other deamatiaceous hyphomycetes growing on wood. *Stud. Mycol.* 13: 1-99.

HASHMI, M.H., G. MORGAN-JONES and B. KENDRICK. 1973. Conidium ontogeny in hyphomycetes. The blastoconidia of *Cladosporium herbarum* and *Torula herbarum*. *Can. J. Bot.* 41: 459-468.

HUGHES, S.J. 1958. Revisiones hyphomycetum aliquot cum appendice de nominibus rejiciendis. *Can. J. Bot.* 36: 727-836.

HUGHES. S.J. 1976. Sooty molds. *Mycologia* 68: 693-820.

KORNERUP, A. and J.H. WANSCHER. 1978. Methuen Handbook of Colour. 3rd Ed. Hastings House, New York, 252 pp.

LINK, H. F. 1809. Observationes in ordines plantarum naturales. *Mag. Ges. naturf. Freunde, Berlin* 3: 3-42.

LINK, H.F. 1815. Observationes in ordines plantarum naturales 2. *Mag. Ges. naturf. Freunde, Berlin* 7: 37-38.

LINK, H.F. 1824. In Linné, Species Plantarum (ed. 4, Willdenow) 6 (1).

MATSUSHIMA, T. 1985. Matsushima Mycological Memoirs 4: 1-68.

MCKEMY, J.M. and G. MORGAN-JONES. 1990. Studies in the genus *Cladosporium sensu lato* II. Concerning *Heterosporium gracile*, the causal organism of leaf spot disease of *Iris* species. *Mycotaxon* 39: 425-440.

MCKEMY, J.M. and G. MORGAN-JONES. 1991. Studies in the genus *Cladosporium sensu lato*. III. Concerning *Cladosporium chlorocephalum* and its synonym *Cladosporium paeoniae*, the causal organism of leaf-blotch of peony. *Mycotaxon* 41: 135-146.

MORGAN-JONES, G. and J.M. MCKEMY. 1990. Studies in the genus *Cladosporium sensu lato*. I. Concerning *Cladosporium uredinicola*, occurring on telial columns of *Cronartium quercuum* and other rusts. *Mycotaxon* 39: 185-202.

MORGAN-JONES, G., R.C. SINCLAIR and A. EICKER. 1991. Notes on Hyphomycetes. LXII. Concerning *Chloridium virescens* var. *allantosporum*, a new taxon, *C. virescens* var. *caudigerum*, and *Chloridium phaeosporum* from southern Africa. *Mycotaxon* 41: 459-468.

PERSOON, C.H. 1794. Nahere Bestimmung und Beschreibungen einiger sich nage verwandter Pflanzen. *Usteri's Ann. Bot.* 7: 1-32.

PERSOON, C.H. 1801. Synopsis methodica fungorum. Gottingen. 694 pp.

PERSOON, C.H. 1822. Mycologia europaea. I. Erlangen.

PRASIL, K. and DE HOOG, G.S. 1988. Variability in *Cladosporium herbarum*. *Trans. Br. mycol. Soc.* 90(1): 49-54.

RUEHLE, G.D. 1930. *Cladosporium* species from apple fruit and the perfect stage of *Cladosporium herbarum* Lk. *Phytopathology* 20: 854.

SACCARDO, P.A. 1886. *Sylloge Fungorum* 4: 1-807.

SUBRAMANIAN, C.V. 1971. Hyphomycetes. An account of Indian species, except Cercosporae. 1st Ed. Indian Council of Agricultural Research, New Delhi, 930 pp.

VON ARX, J.A. 1949. Beitrage zur kenntnis der gattung *Mycosphaerella*. *Sydowia* 3: 28-100.

VON ARX, J.A. 1950. Uber die Ascusform von *Cladosporium herbarum*. *Sydowia* 4: 320-324.

VON ARX, J.A. 1983. *Mycosphaerella* and its anamorphs. *Proc. Konik. Nederl. Akad. Wetens.* C 86: 15-54.

MYCOTAXON

Volume XLII, pp. 319-326 October-December 1991

MISCELLANEOUS NOTES ON INDIAN CERCOSPOREAE

G. BAGYANARAYANA & P. JAGADEESWAR

Department of Botany, Post Graduate College
of Sciences, Osmania University, Saifabad,
Hyderabad, 500004, A.P., India

and

U. BRAUN

Martin-Luther-Universität, FB. Biologie,
Institut für Geobotanik und Botanischer
Garten, Neuwerk 21, D-O-4010 Halle/S.
Germany

SUMMARY

24 Indian Cercosporeae, mainly collected in Andhra Pradesh in 1990, are recorded in the present paper. 5 new species are described. The type material is deposited in HAL.

(1) Cercospora agerati-conyzoidis spec. nov.

Leaf spots amphigenous, subcircular to angular, irregular, ochraceous, dull brown, greyish brown, 1-5 mm diam., or confluent and larger, margin indefinite, mycelium internal, stromata absent or a few swollen, brown hyphae, substomatal. Conidiophores solitary or in small groups (2-6), c. 80-250 x 3.5-6 µm, simple, straight, subcylindric, slightly geniculate-sinuous, brown, paler above, septate, smooth, conidial scars conspicuous, thickened, darkened. Conidia formed singly, acicular, c. 80-120 x 3-4 µm, hyaline, multiseptate, base truncate, hila thickened. Fig. 1

Maculae suborbiculares, angulatae, irregulares, ochraceae, griseo-brunneae, 1-5 mm diam., interdum confluentes, margine indistincto. Mycelium immersum. Stroma non evolutum vel parvum, substomatale. Conidiophora solitaria vel fasciculata (2-6), per stoma emergentia, ca. 80-250 x 3.5-6 µm, erecta, subcylindrica vel leniter geniculata-sinuosa, brunnea, septata, laevia. Cicatrices conidiales conspicuae, incrassatae. Conidia solitaria, acicularia, hyalina, multiseptata, ca. 80-120 x 3-4 µm, basi truncata, incrassata.

Holotypus: on Ageratum conyzoides, India, Hyderabad, Landscape Garden, Osmania University Campus, Nov. 1990, Jagadeeswar & Bagyanarayana (HAL).

Cercospora aciculina Chupp (1954) differs from the new species by shorter conidiophores in dense, rich fascicles. C. conyzoides Thirum. & Govindu (1957) is distinguished by much shorter conidiophores and conidia.

(2) Cercospora atylosiicola spec. nov.

Leaf spots amphigenous, angular-irregular, vein-limited, brown, large, 1-20 mm diam., margin indefinite, mycelium internal, stromata absent or small, substomatal, a few swollen, brown hyphae. Conidiophores solitary or in small fascicles, c. 2-10, through stomata, straight, subcylindric, occasionally slightly geniculate-sinuous in the upper part, c. 60-200 x 4-6 µm, simple, brown, septate, smooth, conidial scars conspicuous, thickened, darkened. Conidia formed singly, acicular, hyaline, multiseptate, c. 80-200 x 2.5-5 µm, smooth, base more or less truncate, hila thickened. Fig. 3

Maculae amphigenae, irregulariter angulatae, brunneae, magnae, 1-20 mm diam., margine indistincto. Mycelium immersum. Stroma non evolutum vel parvum, substomatale. Conidiophora solitaria vel fasciculata (2-10), per stoma emergentia, erecta, subcylindrica vel leniter geniculata-sinuosa, ca. 60-200 x 4-6 µm, brunnea, septata, laevia. Cicatrices conidiales conspicuae, incrassatae. Conidia solitaria, acicularia, hyalina, multiseptata, ca. 80-200 x 2.5-5 µm, laevia, basi truncata, incrassata.

Holotypus: on Atylosia scarabaeoides, India, Hyderabad, Landscape Garden, Osmania University Campus, Nov. 1990, Jagadeeswar & Bagyanarayana (HAL).

Cercospora atylosiae Thirum. & Govindu (1953) differs from the new species by rich, dense fascicles of short conidiophores arising from large stromata. The conidia are much shorter.

(3) Cercospora borreriae-strictae spec. nov.

Leaf spots amphigenous, subcircular to somewhat irregular or diffuse and larger, greyish, dull brown, pale brown, margin indefinite or with narrow, somewhat darker and slightly raised marginal line, caespituli amphigenous, dark brown, mycelium internal, stromata absent or small, 10-30 µm diam. Conidiophores fasciculate (2-10), through stomata, straight, subcylindric to slightly geniculate-sinuous, c. 30-140 x 3-6 µm, simple, brown, septate, smooth, conidial scars conspicuous, thickened, darkened. Conidia solitary, acicular, 50-250 x 2-4 µm, obscurely multiseptate, hyaline, smooth, base truncate, hila thick-

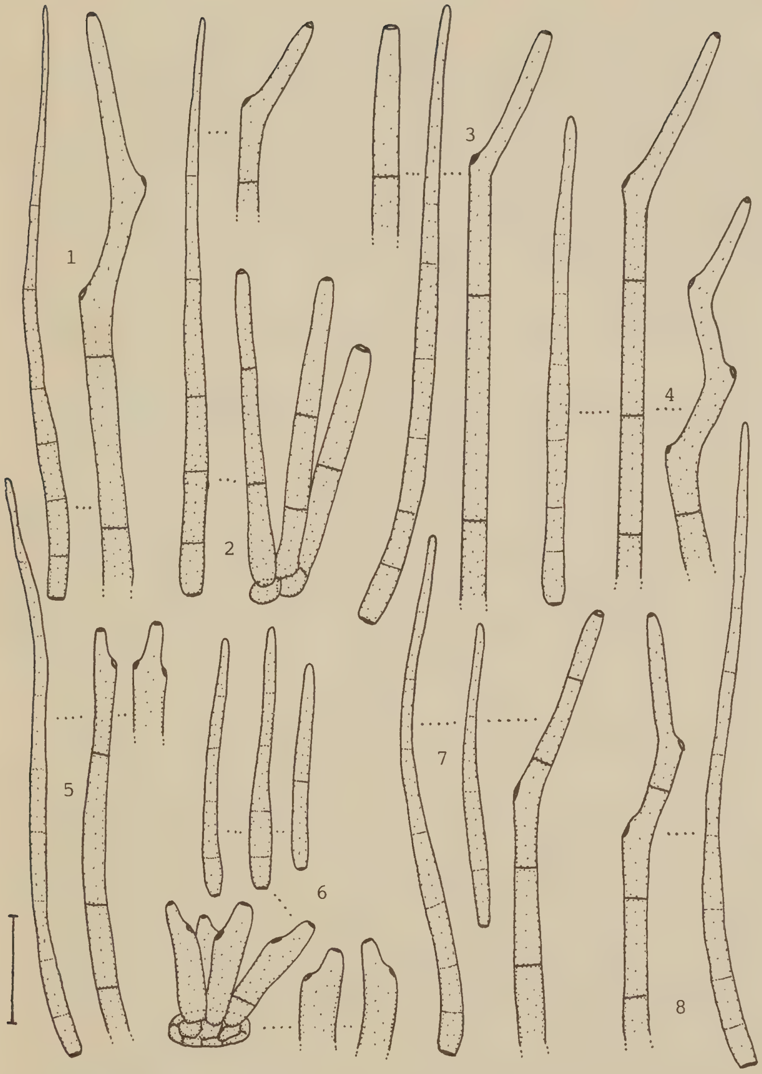


Fig. 1-8: Conidiophores, fascicles, conidia; 1 - Cercospora agerati-conyzoidis, 2 - C. borreriae-strictae, 3 - C. atylosiicola, 4 - C. bombacis, 5 - C. asplenifoliae, 6 - C. celosiae, 7 - C. guatemalensis, 8 - C. malvacearum. Scale bar = 20 µm, U. Braun del.

ened. Fig.2

Maculae amphigenae, suborbiculares vel irregulares, ca. 2-5 mm diam., vel diffusae, magnae, griseo-brunneae, pallide brunneae, margine indistincto vel angusti atrobrunneo cinctae. Caespituli amphigeni, atrobrunnei. Stroma non evolutum vel parvum, substomatale, ca. 10-30 µm diam. Conidiophora fasciculata (2-10), per stoma emergentia, erecta, subcylindrica vel leniter geniculata, ca. 30-140 x 3-6 µm, brunnea, septata, laevia. Cicatrices conidiales conspicuae, incrassatae. Conidia solitaria, acicularia, hyalina, multiseptata, 50-250 x 2-4 µm, basi truncata, incrassata.

Holotypus: on Borreria stricta, India, Yellore, Mahabubnagar, Sept. 1990, Jagadeeswar (HAL).

There are two Cercospora s.l. species on Borreria. But C. borreriae Ell. & Ev. and C. ubatubensis Chupp & Viégas belong to Pseudocercospora (cf. Deighton 1976).

(4) Pseudocercospora pseudotrichodesmatis spec. nov.

Leaf spots absent or only slightly darkened, diffuse areas, caespituli hypophyllous, dull brown, mycelium internal, forming small, substomatal stromata, composed of a few swollen, brown hyphae. Conidiophores solitary or in small, loose fascicles, through stomata, c. 2-12, very long, 40-250 x 4-5 µm, simple, straight, subcylindric to geniculate-sinuous, richly septate, smooth, brown, paler towards the apex, apically frequently denticulate, conidial scars unthickened, not darkened. Conidia solitary, 20-60 x 4-7 µm, subcylindric, clavate, obclavate, (0-) 1-5-septate, faintly olivaceous, smooth, occasionally vacuolate, constricted, apex obtuse, base truncate, hila unthickened. Fig. 11

Maculae nullae vel diffusae. Caespituli hypophylli, brunnei. Mycelium immersum. Stromata substomatalia, plerumque aegre evoluta. Conidiophora solitaria vel fasciculata (2-12), per stoma emergentia, 40-250 x 4-5 µm, simplicia, erecta, subcylindrica vel geniculata-sinuosa, pluriseptata, laevia, brunnea, apice pallidiora, denticulata. Cicatrices conidiales inconspicuae, non incrassatae. Conidia solitaria, 20-60 x 4-7 µm, subcylindrica, clavata, obclavata, (0-) 1-5 septata, pallide olivacea, laevia, interdum vacuolata, constricta, apice obtusa, basi truncata, non incrassata.

Holotypus: on Trichodesma spec., India, Hyderabad, Osmania University Campus, Oct. 1990, Jagadeeswar & Bagyanarayana (HAL).

Cercospora trichodesmatis ("trichodesmae") Govindu & Thirumalachar (1955) is characterized by rich, dense conidiophore fascicles, shorter conidiophores without

denticles and conidia with 1-12 septa.

(5) Pseudocercospora rhynchosiicola spec. nov.

Leaf spots amphigenous, subcircular to irregular-angular, 1-5 mm diam., pale greenish, later yellowish-ochraceous, greyish-white, margin indefinite or with narrow, dark marginal line, caespituli amphigenous, mostly epiphyllous, dark olivaceous brown, mycelium internal, forming large, coloured, substomatal stromata, 20-60 µm diam. Conidiophores in very rich, dense fascicles, arising from stromata, through stomata, short, 5-15 (-20) x 2-3 µm, straight, subcylindric, conic to slightly geniculate-sinuous, aseptate, smooth, olivaceous, conidial scars inconspicuous. Conidia solitary, cylindric, acicular, linear, c.60-100 x 1.5-2.5 µm, obscurely multiseptate, smooth, olivaceous, apex obtuse to subacute, base rounded to truncate, hila unthickened. Fig. 12

Maculae amphigenae, suborbiculares, irregulares, angulatae, 1-5 mm diam., pallide viridulae, flavidae-ochraceae vel griseo-albae, margine indistincto vel margine angusti atrobrunneo cinctae. Caespituli amphigeni, plerumque epiphylli, olivaceo-brunnei. Mycelium immersum. Stromata bene evoluta, 20-60 µm diam. Conidiophora dense fasciculata, 5-15 (-20) x 2-3 µm, erecta, subcylindrica, conica vel leniter geniculata-sinuosa, non septata, laevia, olivacea. Cicatrices conidiales inconspicuae. Conidia solitaria, cylindrica, acicularia, lineata, ca. 60-100 x 1.5-2.5 µm, indistincte multiseptata, pallide olivacea, laevia, apice obtusa vel subacuta, basi rotundata vel truncata, non incrassata.

Holotypus: on Rhynchosia spec., India, Yellore, Mahabubnagar, A.P., Sept. 1990, Jagadeeswar (H A L).

Cercospora rhynchosiae Pavgi & Singh (1964) differs from the new species by longer conidiophores (c. 20-85 x 3-4 µm) in small fascicles and C. rhynchosiae-minimae Thirumalachar & Govindu (1953) is characterized by superficial mycelium with solitary conidiophores.

Some additional species of the Cercosporeae

Cercospora asplenifoliae Narain & Mehrotra, Sydowia 24 (1-6), p.328 "1970" (1971), on Launea nudicaulis, India, Hyderabad, Oct. 1990, Jagadeeswar & Bagyanarayana (conidiophores in small fascicles, c. 70-220 x 3-5 µm, brown, conidia acicular, multiseptate, up to 90 x 2-3 µm, fig. 5).

Cercospora bombacis Goh & Hsieh, Trans mycol. Soc. Rep. China 2(2), p.87-88 (1987), on Bombax ceiba, India, Hyderabad, Nov. 1990, Bagyanarayana (conidiophores up to 250 x 4-6 µm, brown, septate, conidia acicular, hyaline, multiseptate, c. 50-270 x 3-4 µm, fig. 4).

Cercospora canescens Ell. & Mart., Am. Nat. 16, p. 1003 (1882), on *Heylandia latebrosa*, India, Alwal, Hyderabad, Oct. 1990, Bagyanarayana & Jagadeeswar; on *Phaseolus* spec., India, Yellore, Mahabubnagar, Sept. 1990, Jagadeeswar (the fungus on *Heylandia* is characterized as follows: leaf spots subcircular, dull greyish, margin somewhat darker, conidiophores solitary or in small fascicles, up to 180 x 4-6 µm, conidia acicular, hyaline, multiseptate, 50-120 x 2.5-4 µm).

Cercospora celosiae Syd., Ann. Myc. 27, p.430 (1929), on *Celosia argentea*, India, Hyderabad, Oct. 1990, Bagyanarayana & Jagadeeswar (this collection is characterized by unusually short conidiophores, only 5-30 x 4-5 µm, and fairly short conidia, c. 20-60 x 2.5-3.5 µm, fig. 6).

Cercospora citrullina Cooke, Grevillea 12, p.31 (1883), on *Bryonopsis laciniata*, India, Hyderabad, Nov. 1990, Jagadeeswar & Bagyanarayana.

Cercospora gaillardiae Chiddarwar, Ind. Phytopathol. 12(2), p.112 (1959), on *Gaillardia* spec., India, Hyderabad, Nov. 1990, Jagadeeswar & Bagyanarayana.

Cercospora guatemalensis Muller & Chupp, Ceiba 1, p. 173 (1950), on *Ocimum basilicum*, India, Yellore, Mahabubnagar, Sept. 1990, Jagadeeswar (leaf spots subcircular to irregular, greyish-white, dull brown, 1-5 mm diam., margin somewhat darker, conidiophores solitary or in small fascicles, through stomata, simple, long, up to 350 x 3-7 µm, brown, septate, conidia solitary, acicular, hyaline, multiseptate, up to 175 x 2.5-4 µm, fig. 7).

Cercospora ipomoeae Winter, in Rabenh., Fungi eur. et extraeur. exs. 3585, Leipzig 1886, on *Convolvulus* spec. India, Hyderabad, Oct. 1990, Bagyanarayana; on *Ipomoea hederacea*, India, Hyderabad, Oct. 1990, Jagadeeswar.

Cercospora malvacearum Chiddarwar, Ind. Phytopathol. 12(2), p.119 (1959), on *Abutilon indicum*, India, Hyderabad, Oct. 1990, Jagadeeswar & Bagyanarayana (the conidiophores in this collection are 80-250 x 3-7 µm and the long acicular conidia are 3-5 µm wide, fig. 8).

Cercospora spermococes Thirum. & Govindu, Sydowia 16, p.286 (1963), on *Spermococe* spec., India, Alwal, Hyderabad, Oct. 1990, Bagyanarayana.

Phaeoramularia ajrekari (H. & P. Syd.) Deighton, in Ellis, More Dematiaceous Hyphomycetes, p.319, Kew 1976, on *Jatropha* spec., India, Hyderabad, July 1990, Jagadeeswar & Bagyanarayana (conidiophores 8-20 x 3-5.5 µm, densely fasciculate, conidia subcylindric, (15-) 20-50 x 4-6 µm, fig. 9).

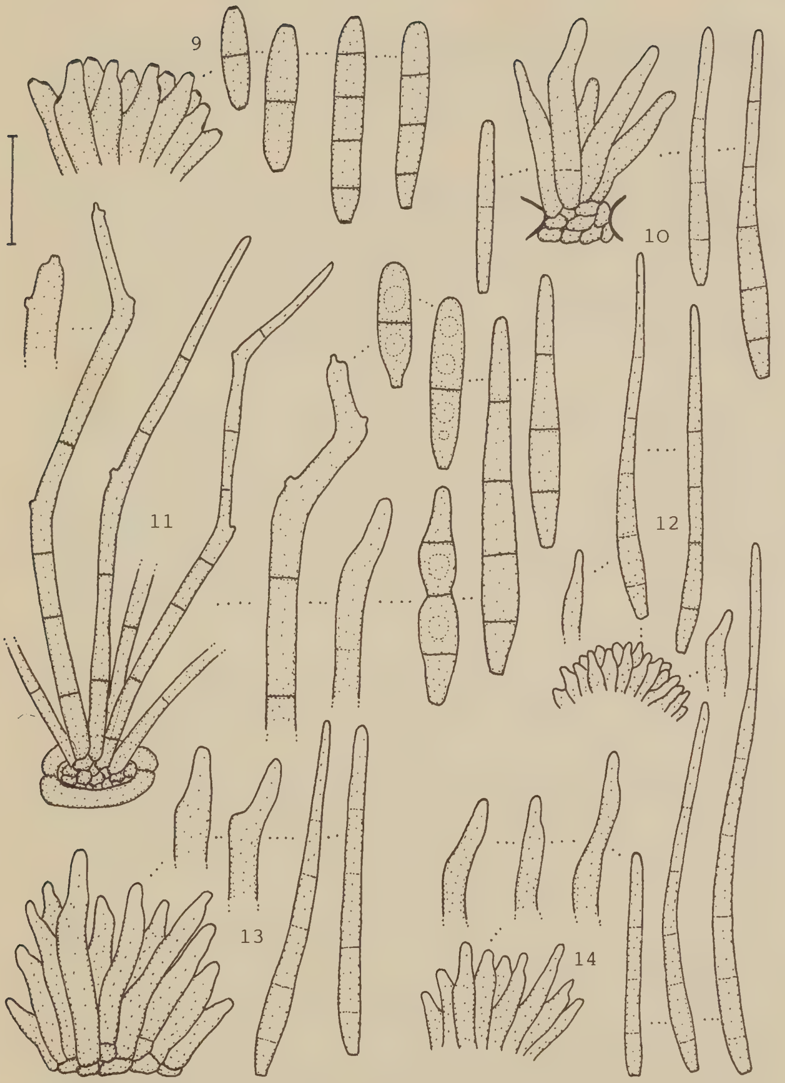


Fig. 9-14: Conidiophores, fascicles, conidia; 9 - Phaeoramularia ajrekari, 10 - Pseudocercospora eupatorii, 11 - P. pseudotrichodesmatis, 12 - P. rhynchosiicola, 13 - P. riachuelii, 14 - P. waltheriae. Scale bar = 20 µm, U. Braun del.

Pseudocercospora cajanicola (Pavgi & Singh) Deighton, Trans. Br. mycol. Soc. 88(3), p.390 (1987), on *Cajanus cajan*, India, Yellore, Mahabubnagar, Sept. 1990, Jagadeeswar (this is a mixed collection together with *Mycovellosiella cajani* var. *indica* (Singh) Deighton and *Cercospora instabilis* Rangel).

Pseudocercospora eupatorii (Peck) U. Braun & R. F. Castañeda, Crypt. Bot. (1991), in print, syn.: *Cercospora eupatorii* Peck, Ann. Rep. N.Y. State Mus. Nat. Hist. 33, p.29 (1880), on *Eupatorium* spec., India, Hyderabad, Nov. 1990, Jagadeeswar & Bagyanarayana (conidiophores in small, fairly loose fascicles, from small substomatal stromata, simple, 8-20 x 2-4.5 µm, olivaceous, conidia solitary, subcylindric, obclavate, 20-70 x 2-3.5 µm, 1-6-septate, subhyaline to faintly olivaceous, fig. 10).

Pseudocercospora jasminicola Deighton, Mycol. Pap. 140, p.74 (1976), on *Jasminum* spec., India, Hyderabad, Nov. 1990, Jagadeeswar & Bagyanarayana.

Pseudocercospora riachueli (Speg.) Deighton, Myc. Pap. 140, p.129 (1976), on *Cayratia trifolia*, India, Hyderabad, Nov. 1990, Jagadeeswar & Bagyanarayana (conidiophores in dense, rich fascicles, 8-30 x 3-5 µm, conidia solitary, subcylindric, narrowly obclavate, subhyaline to pale olivaceous, (20-) 50-100 (-120) x 2.5-5 µm, 4-8-septate, fig. 13).

Pseudocercospora subsessilis (H. & P. Syd.) Deighton, Myc. Pap. 140, p.154 (1976), on *Melia azederach*, India, Hyderabad, Oct. 1990, Jagadeeswar & Bagyanarayana.

Pseudocercospora waltheriae (Thirum. & Chupp) Deighton, Myc. Pap. 140, p.155 (1976), on *Waltheria indica*, India, Hyderabad, July 1990, Jagadeeswar & Bagyanarayana (conidiophores densely fasciculate, 5-25 x 2-4 µm, conidia subcylindric, acicular, narrowly obclavate, 30-125 x 2-3.5 µm, fig. 14).

References

Chupp, C. (1954): A monograph of the fungus genus *Cercospora*. Ithaca, New York.

Deighton, F. C. (1976): Studies on *Cercospora* and allied genera. VI. *Pseudocercospora* Speg., *Pantospora* Cif. and *Cercoseptoria* Petr. Myc. Pap. 140, 1-168.

Govindu, H. C. & M. J. Thirumalachar (1955): Notes on some Indian Cercosporae - VI. Sydowia 9, 221-228.

Pavgi, M. S. & V. P. Singh (1964): Parasitic fungi from North India. Mycopathol. mycol. appl. 23, 188-195.

Thirumalachar, M. J. & H. C. Govindu (1953): Notes on some Cercosporae of India - II. Sydowia 7, 45-49.

-- & -- (1957): Notes on some Cercosporae of India - VII. Sydowia 10, 221-228.

MYCOTAXON

Volume XLII, pp. 327-332 October-December 1991

NEW COMBINATIONS AND NEW SYNONYMS IN THE GENUS CLAUSSENOMYCES

TERESITA ITURRIAGA

División de Ciencias Biológicas, Universidad Simón Bolívar
Apdo. post. 89000, Caracas 1081-A, Venezuela

INTRODUCTION

The genus *Claussenomyces* was erected by Kirschstein (1923), for *C. jahnianus* Kirsch. According to Korf & Abawi (1971), "Kirschstein had earlier orally described his new fungus in *Holwaya*, which Harms (1917) inadvertently misspelled *'Holmaya.' Holwaya jahniana* Kirschst. in Harms is technically a nomen nudum, however." The genus *Claussenomyces* has frequently been called *Corynella* Boudier 1885, which is a later homonym of *Corynella* de Candolle 1825, in the Leguminosae.

Three species were added by Korf & Abawi (1973), *C. pusillus* (Rehm) Korf & Abawi, *C. atrovirens* (Pers. : Fr.) Korf & Abawi, and *C. prasinulus* (Karst.) Korf & Abawi. Ouellette & Pirozynski (1974) added two additional taxa, *C. pseudotsugae* (Groves) Ouel. & Piroz. and *C. luteoviridis* Ouel. & Korf in Ouel. & Piroz., and in the same year Dixon (1974) added *C. salviicolor* (Ell. & Ev.) Korf & Dixon in Dixon. That species was later transferred out of the genus, as *Chlorociboria salviicolor* (Ell. & Ev.) Korf in Ouellette & Korf (1979), when three additional species were added: *Claussenomyces canariensis* Ouel. & Korf, *C. clavatus* Ouel. & Korf, and *C. dacrymycetoideus* Ouel. & Korf. A further emendation of the genus was made by Hawksworth & Sherwood (1981), who included *C. olivaceus* (Fuckel) Sherw. in Hawksw. & Sherw. Iturriaga (1984) added *Belonidium viridi-atrum* Sacc. & Fautr. and *Strossmayeria viridi-atra* (Sacc. & Fautr.) Dennis to the synonymy of *C. prasinulus*. Two more species have been added more recently to the genus, *C. pini* Funk (1986) and *C. hydnicola* (Berk. & Curt.) Korf & Zhuang (1986).

NEW COMBINATIONS FOR TWO SPECIES REPLACING TWO NAMES IN CURRENT USE IN CLAUSSENOMYCES

Claussenomyces imperspicuus (Sacc., Bomm., & Rouss.) Iturriaga & Korf, *comb. nov.*

≡ *Belonidium imperspicuum* Sacc., Bomm., & Rouss., *Mem. Soc. Roy. Belg.* **29:** 222. 1890.

= *Claussenomyces luteoviridis* Ouel. & Korf *in* Ouellete & Pirozynski, *Can. J. Bot.* **52:** 1909. 1974.

Apothecia dark-green, almost black when dry, olive-green when rehydrated, 0.5 mm diameter, with a short stipe, concave, with a fimbriate margin, single or gregarious. Ionomidotic reaction not present in 2% KOH. Ectal excipulum of textura intricata in a gel, cells rectangularly elongated, 0.7-1.5 µm wide, sometimes with globose elements 2.2-2.9 µm in diam. Asci arising from croziers, clavate, (82.1-) 93.3 - 106.5 X 11.2 - 14.9 (-16.8) µm. Ascospores frequently biseriate, sometimes clavate-fusiform, at other times cylindric to fusiform, most commonly fusiform, multiseptate, budding inside the ascus and sometimes filling it completely with ascoconidia, (3-) 7-12-septate, often a few cells of each ascospore with longitudinal or oblique septa, 12.4 - 23.0 X 2.2 - 4.0 µm, smaller ascospores with fewer septa than larger ones. Ascoconidia cylindrical, small, 1.5 - 2.9 (–3.7) X 0.7 - 1.5 µm. Paraphyses simple or most frequently divided near the tip, end cells rounded to sometimes bulbous, 0.7-1.5 µm wide in the middle, 1.5-2.2 µm wide at the apex.

Holotype: Sur un tronc de charme abattu. Groenendael. Oct. 1887. Leg. M. R[ousseau], BR.

Type locality: Groenendael, Belgium.

Habitat: On fallen decomposed trunk of unknown hosts, and *Carpinus betulus.*

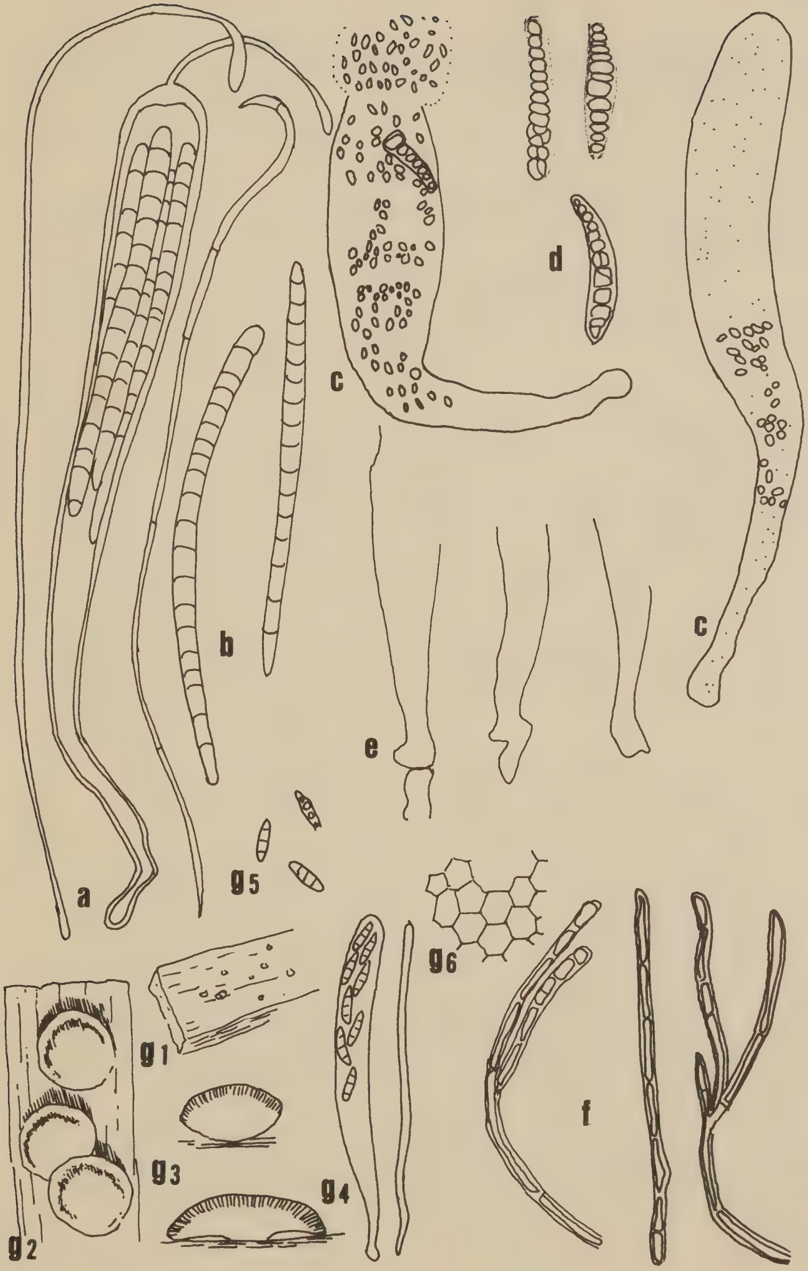
Distribution: Groenendael, Belgium; Boitsfort, France; Puerto Rico.

Other specimens examined: *Belonidium imperspicuum* B. R. et *Zygnnella pygmaea* (K.) Lee, Sur le bois pourrisant du *Carpinus betulus,* Boitsfort 3/90, 1668, PAD. On unidentified wood, S of El Verde, Hwy. 186, km 17 turn off to Rd 911, El Yunque, Puerto Rico, leg. R. P. Korf et al., 6.ix.1970, HT of *Claussenomyces luteoviridis,* CUP-PR 3937.

Illustrations: This paper, Fig. 1 c-f; Ouellette & Pirozynski, *Can. J. Bot.* **52,** Fig. 69-72. 1974.

Etymology: The epithet imperspicuum means almost not perceptible, probably because of the small size and dark color of this fungus.

Fig 1. *Claussenomyces* spp. **a & b**. *Claussenomyces tympanoides*.**a**. Asci & paraphyses. **b.** Ascospores. Both x1000, from the HT. **c.-f** *Claussenomyces imperspicuus*. **c**. Asci with microconidia. **d.** Ascospores. **e**. Bases of asci. **f.** Paraphysis tips. All x1000. Authentic. **g.** *Belonidium clarkei,* from Massee & Crossland, The Naturalist **1901:** pl. 1, figs. 1-6. 1901. **g-1**. apothecia natural size; **g-2**. enlarged x10; **g-3**. Sections x20-24; **g-4**. ascus, spores and paraphyses x450; **g-5**. Ascospores; **g-6**. cortical cells x400.


a
b
c
c
d
e
f
g1
g2
g3
g4
g5
g6

Notes: In general measurements made by the author are a little smaller than the ones made by Ouellette & Korf, 1974.

Claussenomyces tympanoides (Ellis & Everhart) Iturriaga & Korf, *comb. nov.*

≡ *Belonidium tympanoides* Ellis & Everhart, *Proc. Acad. Sci. Phila.:* 149. 1893.

≡ *Belonium tympanoides* (Ellis & Ev.) Seaver, *The North American Cup-Fungi (Inoperculates):* 171. 1951.

= *Claussenomyces pusillus* (Rehm) Korf & Abawi, *Can. J. Bot.* **49**: 1882. 1971.

≡ *Holwaya pusilla* Rehm, *Ann. Mycol.* **4**.: 337. 1906.

Apothecia black, sessile, discoid, 0.5-0.75 mm in diam., closed when dry. Ionomidotic reaction present in 2% KOH. Ectal excipulum of textura intricata immersed in a gel. Medullary excipulum of textura intricata with hyphae widely spaced and immersed in a gel, cells 1.5-2.9 µm wide. Asci arising from croziers, clavate, (112.2-) 125.4 - 149.7 (-164.7) x 11.2 - 13.1 µm, with a depression in the inner wall apex, apex thickened, basal portion long and narrow, 3.7 µm wide at the base. Ascospores filiform, one end rounded, other end tapering to a point, hyaline, (49.2-) 50.6 - 62.3 x 2.2 - 2.9 µm, 15 (-17) septate, ascospores in the upper portion of the ascus. Ascoconidia eventually fill the ascus. Paraphysis filiform with circinate (coiled) tips forming an epithecium, septate, 0.7 µm wide, simple or divided.

Holotype: A black peziza, London, Canada, Sept. 1889, J. Dearness. Ellis 948 NY.

Isotype: Ellis 948 NY.

Type locality: London, Ont., Canada.

Habitat: On rotted wood.

Distribution: Canada, U.S.A.

Other specimens examined: C. E. Fairman 1953, on wood, in the woods, Lyndonville, N. Y., May 1906 (as *Holwaya pusilla)* (Topotype: CUP-F); C. E. Fairman 3879, on rotten limb in wood pile, Lyndonville, N. Y., Jan. 7, 1913 (as *Holwaya pusilla*) (Topotype: CUP-F).

Illustrations: This paper, Fig. 1 a, b; Korf & Abawi, *Can. J. Bot.* **49,** Pl. 1, Fig. 4 (clavate ascus with irregularly disposed ascospores) (as *C. pusillus).*

Etymology: the epithet *tympanoides* is in reference to the genus *Tympanis,* which is characterized by having asci filled with many secondary spores.

Notes: There are two collections in the Ellis collection (NY) with the same number, 948. I will recognize as the Holotype the one that bears the collecting data and date, which is also the one that has the “Ellis Collection” seal from NY. The other collection remains as an isotype and has a description on the label, but no collection data. *Belonium tympanoides* (Ell. & Ev.) Seaver, is merely a transfer, with the description being almost identical to Ellis & Everhart's.

AN ADDITIONAL SYNONYM FOR CLAUSSENOMYCES PRASINULUS

To the already extensive synonymy of *Claussenomyces prasinulus* (Karst.) Korf & Abawi can be added one additional name:

Belonidium clarkii Massee & Crossland, The Naturalist **1901:** 181. 1901. The following information applies to that name:

Holotype of *Belonidium clarkii* Mass. & Crossl., On damp, rotten wood, Mulgrave Woods, Whitby, Y. N. U. Foray, September 1900, (A. Clarke) (NY).

Other specimens examined labelled *Belonidium clarkii* : On rotting wood, Derbyshire, Oct. 17, 1901, (illegible) Gibbs (Authentic) (K); On rotting oak branch, Rokeby, Y. N. U. Fungus Foray, 1904 (Sep.), Herb. C. Crossland (K).

Illustrations: Massee & Crossland, The Naturalist:**1901:** 184, pl. 1, figs. 1-6. 1901.

The synonymy and description of *C. prasinulus* would then be:

Claussenomyces prasinulus (Karst.) Korf & Abawi, Can. J. Bot. 49: 1882. 1971.

≡ *Peziza prasinula* Karst., *Not. Sällsk. F. Fl. Fenn.* **10:** 155. 1869.

≡ *Ombrophila atrovirens* (Pers. ex Fr.) Karst. var *prasinula* (Karst.) Karst., *Mycol. Fenn.* **1:** 93. 1871.

≡ *Ombrophila prasinula* (Karst.) Rehm , *Hedwigia* **21:** 71. 1882.

≡ *Coryne prasinula* (Karst.) Rehm *in* Rabenh., Krypt.-flora, 2 Aufl., 1 (Pilze), **3**: 486. 1891.

≡ *Corynella prasinula* (Karst.) Boud., Hist. & Class. Discom. d'Europe: 99. 1907.

= *Helotium glabrovirens* Boud., *Bull. Soc. Bot. Fr.* **28:** 95. 1881.

≡ *Corynella glabrovirens* (Boud.) Boud., *Bull. Soc. Mycol. Fr.* **1:** 114. 1885.

= *Belonidium viridi-atrum* Sacc. & Fautr., *Bull. Soc. Mycol. France* **16:** 22. 1900.

≡ *Strossmayeria viridi-atra* (Sacc. & Fautr.) Dennis, *Persoonia* **2** (2): 188. 1962.

= *Belonidium clarkii* Massee & Crossl., The Naturalist **1901:** 181. 1901.

Apothecia black when dry, greenish when rehydrated, flat, sessile, appressed to the substrate, pulvinate, 0.5-0.75 mm diameter. Ectal excipulum at the margin of textura oblita, composed of hyphae inmersed in a gel; at the flanks of textura globulosa, cells inmersed in a gel, 7.5-11 µm in diameter. Hymenium light green. Asci arising from repeating croziers, clavate, ascus pore J-, 66-74 x 6-8 µm. Ascospores 8, hyaline, cylindric-fusiform, 3-septate, slightly constricted at the septa, budding inside the ascus, uniseriate or biseriate, 9.9-13.5 x 2.7-3.6 µm. Paraphyses filiform, divided, 1 µm thick throughout.

ACKNOWLEDGEMENTS

I thank Professor Richard P. Korf, Department of Plant Pathology, Cornell University, for acting as a presubmission reviewer.

REFERENCES

Beaton, G. & G. Weste. 1978. Four inoperculate discomycetes from Victoria, Australia. Trans. Brit. Mycol. Soc. **71:** 215-221.

Dixon, J. R. 1974. Chlorosplenium and its segregates. I. Introduction and the genus Chlorosplenium. Mycotaxon **1:** 65-104.

Funk, A. 1986. Two new discomycetes on Pinus. Mycotaxon **27:** 283-288.

Harms, H. 1917. Tagesordnung der Sitzungen im abgelaufenen Geschäfts–jahre. Verh. Bot. Vereins Prov. Brandenburg **58:** 226-262.

Hawksworth, D. L. and M. A. Sherwood. 1981. A reassessment of three widespread resinicolous discomycetes. Canad. J. Bot. **59:** 357-372.

Iturriaga, T. 1984. Studies in the genus Strossmayeria (Helotiales). 1. Generic delimitation. 2. Two lost species. 3. Three excluded species. Mycotaxon **20:** 169-178.

Kirschstein, W. 1923. Ein neuer markischer Discomycet. Verh. Bot. Vereins. Prov. Brandenburg **65:** 122-124.

Korf, R. P. and G. S. Abawi. 1971. On Holwaya, Crinula, Claussenomyces, and Corynella. Canad. J. Bot. **49:** 1879-1883. pl. I.

Korf, R. P. and W.-y. Zhuang. 1987. On the genus Pithyella and its later synonym, Helotiopsis (Leotiaceae). Mycotaxon **29:** 1-10.

Ouellette, G. B. and R. P. Korf. 1979. Three new species of Claussenomyces from Macaronesia. Mycotaxon **10:** 255-264.

Ouellette, G. B. and K. A. Pirozynski. 1974. Reassessment of Tympanis based on types of ascospore germination within asci. Canad. J. Bot. **52:** 1889-1911, pl. I-VII.

MYCOTAXON

Volume XLII, pp. 333-338 October-December 1991

Alpine and subalpine fungi of the Cascade and Olympic Mountains.
2. *Macowanites lymanensis* sp. nov.

EFREN CAZARES AND JAMES M. TRAPPE

Department of Botany and Plant Pathology, Oregon State University, Corvallis, Oregon 97331

ABSTRACT

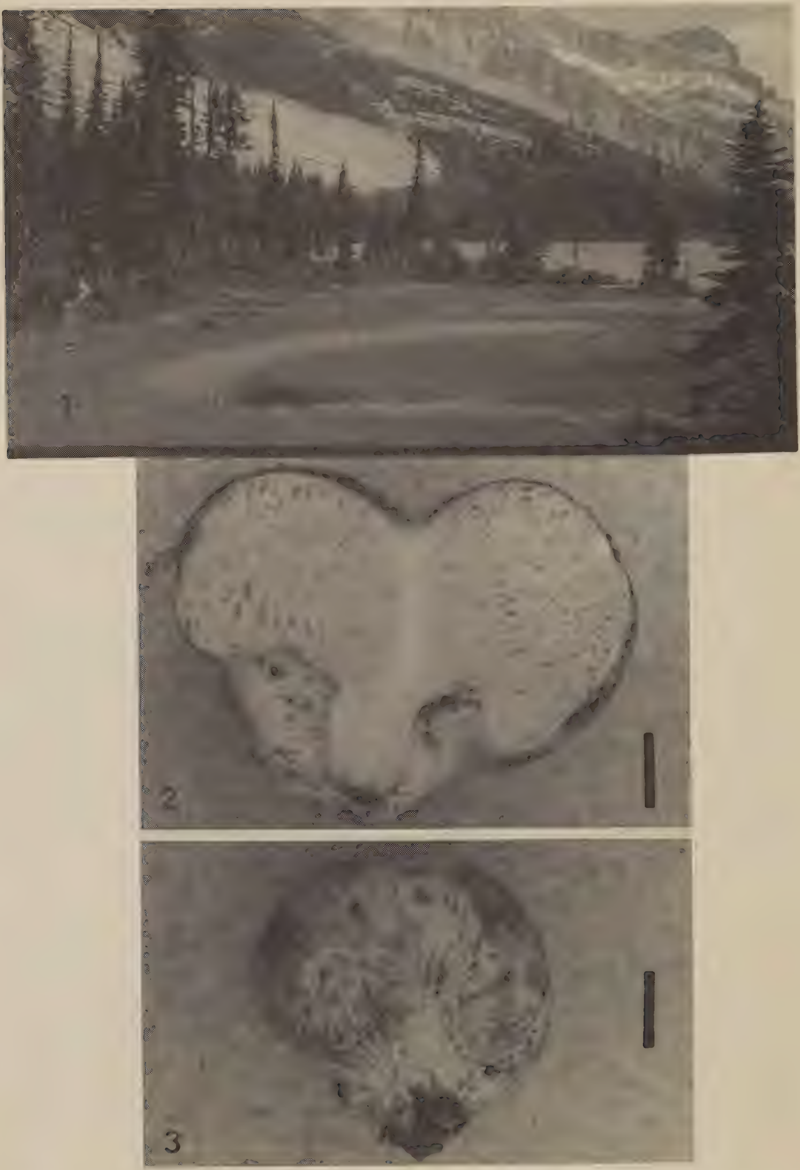
A new *Macowanites* species is described from near Lyman Lake, Glacier Peak Wilderness Area, in the North Cascade Range, Washington.

INTRODUCTION

Lyman Lake is in the Glacier Peak Wilderness Area of the Wenatchee National Forest, North Cascade Mountains, Chelan County, Washington. Fig. 1 The vegetation is typical for mountain hemlock [*Tsuga mertensiana* (Bong.) Carr.] subalpine forests (Franklin and Dyrness, **1973**). In the old forest on the north and west shores of Lyman Lake, where this new species was found, the dominant tree species in addition to mountain hemlock are noble fir (*Abies procera* Rehd.), Pacific silver fir (*Abies amabilis* Dougl. ex Forbes) and subalpine fir [*Abies lasiocarpa* (Hook.) Nutt.]. The mountain hemlock zone is wet and cool: the annual precipitation at Lyman Lake averages 2750 mm, mostly as snow which accumulates from November through April (Mann and Dull, **1979**). The fleshy fungi fruit primarily July through September.

METHODS

A single collection of several sporocarps was noticed because several sporocarps were emergent in the bare, compacted soil of a heavily used campsite about 10 m from a small stream. All sporocarps were found in a roughly circular area about 1 m in diam, some single, others in clusters, and a few joined at the base. After fresh characters were recorded, specimens were dried and saved for microscopic study. Microscopic features were described according to Smith (**1963**). Color names and numbers were determined with the ISCC-NBS manual (Kelly and Judd, **1955**).



Figs. 1-3. Fig. 1. Lyman Lake area (Type locality). Fig. 2. Fresh basidiome of ***M. lymanensis*** in cross section. Bar=1 cm. Fig. 3. Exterior of the basidiome and some exposed locules. Bar=1 cm. (Figs. 2 and 3 courtesy of Dr. M. A. Castellano).

DESCRIPTION

Macowanites lymanensis Cázares & Trappe, *sp. nov.*
Figs. 2-5.

BASIDIOMATA *7-23 x 12-36 mm, subglobosa, turbinata, lobata vel depressa.* ***PERIDIUM*** *glabrum, pallide luteolum labibus brunneis, 20-70 µm crassum, hyphis 2-5 µm ad septa, cellulis inflatis usque ad 10-20 µm.* ***GLEBA*** *pallide armeniaca, loculata.* ***STIPES-COLUMELLA*** *alba, vix vel manifeste projecta, percurrens vel truncata.* ***BASIDIA*** *28-45 x 11-17 µm, clavata, sterigmatibus 2-4.* ***SPORAE*** *7-13 (-17) x 7-12 (-14) µm, globosae vel subglobosae, symmetricae, amyloideae, virgis vel verrucis singularibus, lineis vel subreticulo ornatae.* ***HOLOTYPUS:*** *Trappe # 10611 (OSC).*

BASIDIOMATA single to gregarious or caespitose, 7-23 x 12-36 mm in diam, subglobose to turbinate, lobed or depressed at the center. **PERIDIUM** pale dull yellow with brown stains on disc, grading to white towards the margin, glabrous, recurved and often attached to stipe but sometimes separated to reveal the basal locules. **GLEBA** pale orangish yellow (ISCC-NBS 73) or slightly yellower, loculate, locules 0.3-1 mm broad. **STIPE-COLUMELLA** barely projecting or prominent, white, percurrent or truncated, context white. **RHIZOMORPHS** absent. **ODOR** strongly yeasty with a slight wine essence, taste mild.

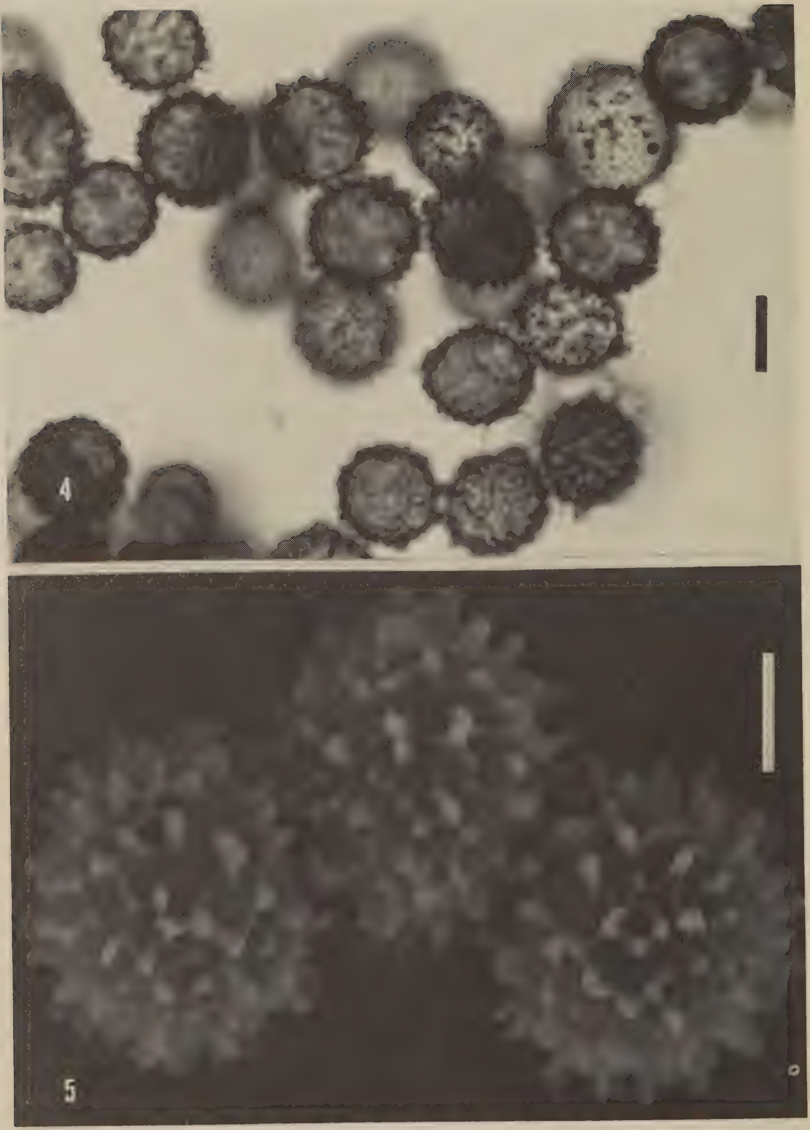
SPORES 7-13 (-17) x 7-12 (-14) µm, excluding ornamentation, globose to subglobose, symmetrical, the wall and ornamentation amyloid, ornamentation 1-2 µm tall, consisting of rods or warts, separate or often connected by lines, occasionally forming a partial reticulum, sterigmal appendage with an amyloid collar or amyloid deposit on one side.

BASIDIA 28-45 x 11-17 µm, thin-walled, clavate, with 2 or 4 sterigmata, hyaline in KOH, pale yellow in Melzer's reagent. **CYSTIDIA** absent.

TRAMA 35-140 µm wide, of thin-walled, hyaline sphaerocysts but ocasionally also with a central strand of interwoven, thin-walled hyphae 3-6 µm in diam at septa. **SUBHYMENIUM** cellular, 1-3 (-5) cells deep, the cells 10-15 (-20) µm in diam, hyaline in KOH, pale yellow in Melzer's reagent. **STIPE-COLUMELLA** of hyaline, thin-walled, tightly interwoven hyphae, 2-8 µm in diam at septa, many cells inflated up to 10-20 µm in diam. Epicutis of **PERIDIUM** 20-70 µm thick, composed of appressed, thin-walled hyphae 2-5 µm in diam at septa, with most cells inflated up to 10-20 µm in diam, light yellow in KOH and Melzer's reagent, and a subcutis composed of thin-walled, hyaline, inflated cells and sphaerocysts 10-40 µm in diam. **CLAMP CONNECTIONS** absent.

ETYMOLOGY: in reference to Lyman Lake, near which the holotype was collected.

HOLOTYPE: Washington, Chelan County, Wenatchee National Forest, Glacier Peak Wilderness Area, Lyman Lake, campsite on E shore near the



Figs. 4-5. ***Macowanites lymanensis***. Fig. 4. Basidiospores (Nomarsky differential interference contrast photomicrograph). Bar=10 µm. Fig. 5. Basidiospores (Scaning Electron photomicrograph). Bar= 5 µm.

inlet of Cloudy Pass Creek, 48° 12' N. Lat., 120° 551 W. Long., elevation 1708 m, hypogeous to emergent in bare, compacted soil among *Abies amabilis-A. lasiocarpa* roots, Jim Trappe # 10611, 25 September 1990 (OSC).

Discussion

The distinctive features of this species are the thin peridial epicutis of appressed hyphae, the relatively large spores with ornamentation 1-2 µm tall, consisting of individual rods or warts often connected in lines or forming a partial reticulum, and a total absence of cystidia. Of the species with similar spores, all have different peridial coloration except *M. citrinus* Singer & Smith. *M. citrinus*, however, has a peridial epicutis comprised of a turf of filaments (Singer & Smith, **1960**) as opposed to the epicutis of appressed hyphae of *M. lymanensis. Macowanites mexicanus* Guzmán and *M. duranguensis* Guzmán recently described from México (Guzmán, **1988**) both have spores with ornamentation < 1 µm tall and cystidia in the hymenium.

Singer and Smith (**1960**) used the presence of sphaerocysts in the glebal mediostratum in *Macowanites* as the major character that distinguishes it from *Elasmomyces*, which lacks these cells in the mediostratum. We have followed this concept in assigning the new species to *Macowanites.* In the scheme of Pegler and Young (**1979**), the species would be placed in *Elasmomyces.* They place genera with statismospores (symmetrical spores that lack the forcible discharge mechanism) in the Elasmomycetaceae, a segregate from the Russulaceae (with asymmetrical ballistospores). As defined by Pegler and Young, the Elasmomycetaceae cuts across the distinct phylogenetic lines leading from *Russula* and *Lactarius* and thus is polyphyletic. We prefer to leave all hypogeous russuloid and lactarioid taxa in the family Russulaceae. The various genera form a continuum from *Russula* and *Lactarius* with pileus, stipe, lamellae and ballistospores to *Gymnomyces* and *Zelleromyces,* respectively, with no pileus or stipe, a peridium-enclosed, loculate gleba, and statismospores. *Macowanites* fits in this continuum between *Russula* and *Gymnomyces. Elasmomyces* and *Martellia* may form a side branch continuum from *Macowanites.*

Acknowledgments

This study was supported by National Science Foundation Grant BSR-8717427 and the U. S. Forest Service, PNW Research Station. Drs. Harry Thiers and Michael Castellano reviewed the manuscript and offered many helpful suggestions. Personnel of the U. S. Forest Service, Wenatchee National Forest, Chelan Ranger District, encouraged and facilitated our field work. SEM photomicrographs were prepared by Dr. Al Soeldner. The senior author thanks "Consejo Nacional de Ciencia y Tecnología" in México for their support.

LITERATURE CITED

Franklin, J. F. and C. T. Dyrness. 1973. Natural Vegetation of Oregon and Washington. USDA For. Serv. Gen. Tech. Rep. PNW-8. 416 p.

Guzmán, G. 1988. Dos nuevas especies de *Macowanites* en México. **Rev. Mex. Mic. 4**: 115-121.

Kelly, K. L. and D. B. Judd. 1955. The ISCC-NBS method of designating colors and a dictionary of color names. U.S. Nat. Bur. of Standards Circ. No. 533. 158p.

Mann, D. L. and K. Dull. 1979. Six years of site restoration at Lyman lake. **In**: Recreational Impact on Wildlands. Conf. Proc. [eds. Ruth Ittner et al.] For. Serv. USDA, National Park Service, USDI. pp. 276-279.

Pegler, D. N. and T. W. K. Young. 1979. The gasteroid Russulales. **Trans. Br. Mycol. Soc. 72**: 353-388.

Singer, R. and A. H. Smith. 1960. Studies on secotiaceous fungi. IX. The astrogastraceous series. **Mem. Torrey Bot. Club 21**: 1-112.

Smith, A. H. 1963. New astrogastraceous fungi from the Pacific Northwest. **Mycologia 55**: 421-441.

MYCOTAXON

Volume XLII, pp. 339-345 October-December 1991

Alpine and subalpine fungi of the Cascade and Olympic Mountains.

3. *Gastroboletus ruber* comb. nov.

EFREN CAZARES AND JAMES M. TRAPPE

Department of Botany and Plant Pathology, Oregon State University, Corvallis, Oregon 97331

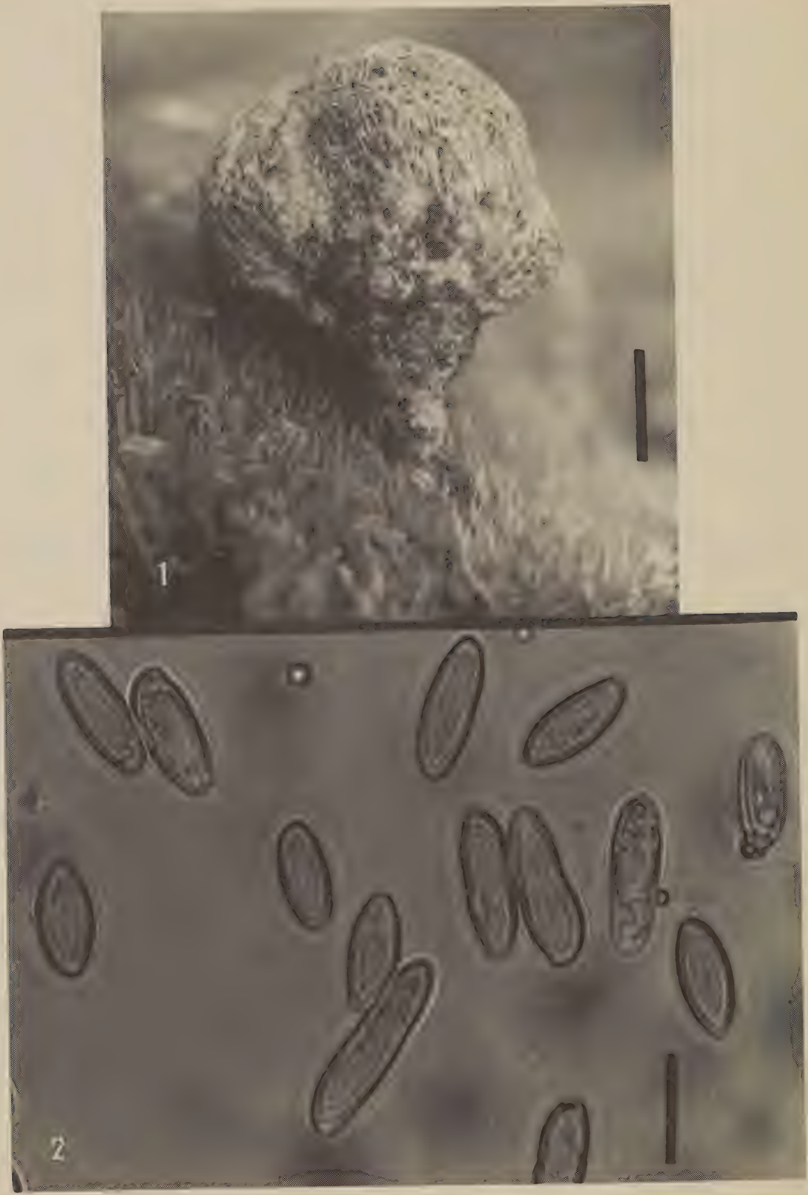
ABSTRACT

A new combination of *Gastroboletus ruber* is made from *Truncocolumella rubra* Zeller. The range of the species in the Cascade mountains is extended from northern Washington to mid Oregon.

INTRODUCTION

Zeller (**1939**) described *Truncocolumella rubra* from a single collection, and Smith & Singer (**1959**) recorded a second collection. Since then, no further material has been reported in the literature. We have seen 13 additional collections, most of them our own and most containing many basidiomata. In 1989 and 1990 we found it fruiting abundantly near Lyman Lake in the Glacier Peak Wilderness Area of the North Cascades, not far from the type locality of *Macowanites lymanensis* Cázares & Trappe (see this issue of *Mycotaxon*). Observing *T. rubra* in its substantial variation, we became aware that it is intermediate between *Gastroboletus* and *Truncocolumella.* This is not surprising, in that evolutionary progression from a gymnocarpic to a angiocarpic habit predictably produces occasional intermediates.

Truncocolumella rubra retains strongly boletoid characters, including asymmetric ballistospores, whereas the type of the genus, *T. citrina,* has lost most boletoid features, has symmetric statismospores, and resembles the genus *Rhizopogon.* Moreover, *T. citrina* seems to have been derived from *Suillus* through *Gastrosuillus,* whereas *T. rubra* is clearly related to *Boletus* through *Gastroboletus.* Accordingly, we regard the placement of *T. rubra* as phylogenetically inappropriate and move the species to *Gastroboletus.* We prefer this solution to the erection of a new monotypic genus, because the *Gastroboletus* affinity of the species is clear and it retains ballistospores.



Figs. 1-2. ***Gastroboletus ruber***. Fig. 1. Fresh basidiome, photo courtesy of Dr. D. Luoma. Bar=1 cm. Fig. 2. Basidiospores (Nomarsky differential interference contrast photomicrograph). Bar=10 µm.

METHODS

Macro- and microscopic features were described according to the standard methods used by Smith & Singer (**1959**). Colors of *G. ruber* sporocarps vary greatly and thus are given in general color terms.

DESCRIPTION

Gastroboletus ruber (Zeller) Cázares & Trappe, comb. nov.

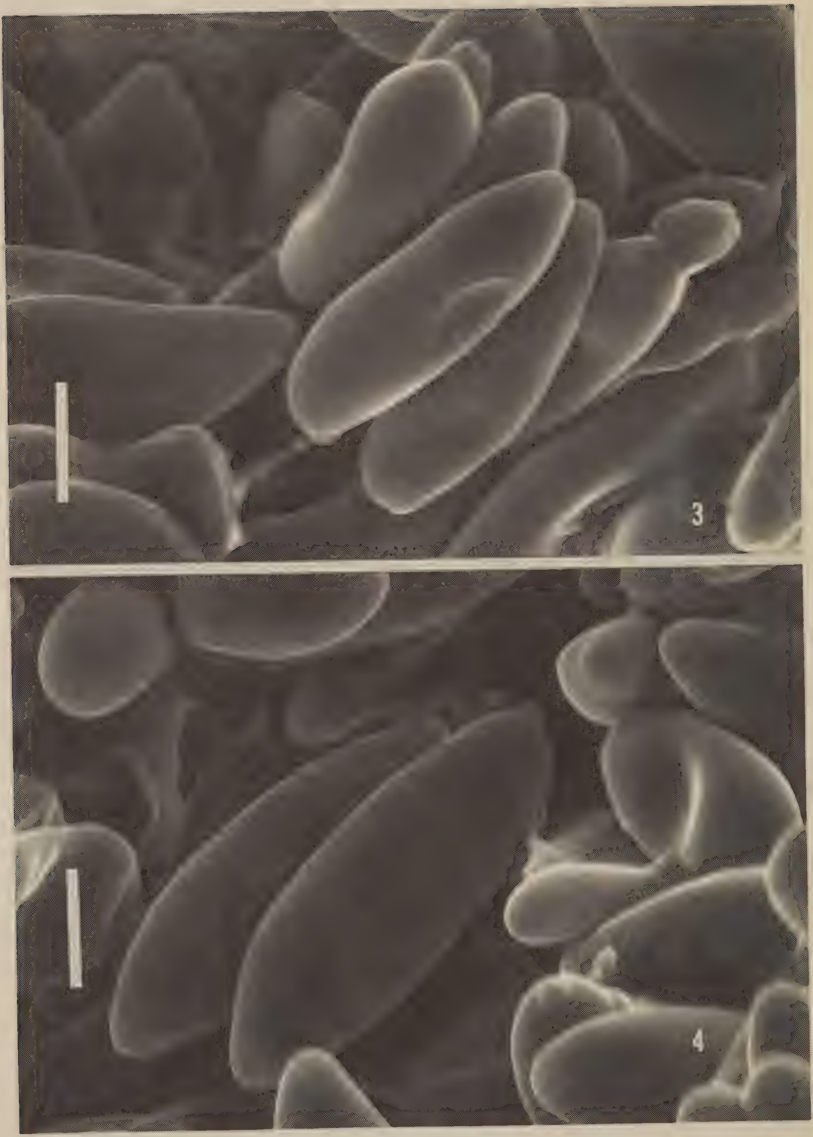
≡*Truncocolumella rubra* Zeller, Mycologia 31:7-8, Figs. 5, 6, 21, 22. 1939.

Figs. 1-5.

BASIDIOMATA 20-40 x 20-55 mm, subglobose to turbinate or lobed, solitary to gregarious or caespitose, hypogeous to emergent. **PERIDIUM** rose to brownish red or reddish brown and persistent on apex of percurrent stipe-columellae, dingy pale yellow to dark reddish brown and usually evanescent where covering mouths of exposed tubular glebal locules but sometimes partially persisting and then becoming yellowish brown to cinnamon and depressed in the tube mouths to give a reticulate appearance. **GLEBA** light yellow in youth, dark olive at maturity, initially of separable tubes 0.5-1 mm in diam divided into labyrinthine locules ±0.2 mm in diam, upon expansion the tubular organization becomes disrupted but the labyrinthine locules still radiate and are up to 0.5 (-0.8) mm in diam, the exposed locule mouths tinged reddish orange to red at maturity, turning blue where bruised or cut, separable from the columella. **STIPE-COLUMELLA** pale yellow with a concolorous context, turning blue instantly where cut, columnar to dendroid, percurrent or not, with many branches reaching or nearly reaching the peridium, projecting as much as 1 cm below the glebal base, up to 1.5 cm broad at the apex when percurrent. Basal hyphae white to pale yellow. **ODOR** not distinctive.

SPORES (8-) 9-15 (-20) x 4-6 µm, smooth, asymmetric, subfusiform, walls up to 0.5 µm thick, pale green to olive in KOH, pale orangish yellow in Melzer's reagent.

BASIDIA 26-40 x 7-11 µm, thin-walled, cylindical to clavate, hyaline, 2- to 4- spored, sterigmata 4-5 µm long. **CYSTIDIA** 25-50 x 4-14 µm, scattered, thin-walled, fusoid-ventricose, hyaline to pale olive in KOH, lacking incrustations. **SUBHYMENIUM** cellular, 2-3 cells deep, cells 3-10 µm in diam. **TRAMA** 25-170 µm thick, of hyaline, thin-walled, subparallel to interwoven hyphae 2-12 µm in diam, laticiferous hyphae occasional. **STIPE-COLUMELLA** composed of thin-walled, hyaline, branched hyphae, 3-12 (-15) µm in diam, laticiferous hyphae scattered near the peridium. **CLAMP CONNECTIONS** absent. **PERIDIAL EPICUTIS** initially differentiated as a palisade of cylindric to clavate dermatocystidia 15-30(-70) x 3-10 µm, hyaline to pale yellow in KOH,



Figs. 3-4. Scaninig electron photomicrographs of basidiospores of ***G. ruber***. Bar=5 µm.

becoming a disrupted turf over the gleba as the basidiome expands but remaining a palisade over the percurrent columellar apices, in age the contents turning yellow to brown.

ETYMOLOGY: Latin, *ruber* (red), in reference to the red mouths of exposed glebal tubes.

DISTRIBUTION, HABITAT, AND SEASON: Cascade Mountains of Oregon and Washington, probably ectomycorrhizal with *Tsuga mertensiana* but *Abies amabilis*, *A. lasiocarpa*, *A. procera*, *Picea engelmannii*, *Pinus contorta* or *P. monticola* often present as well; at elevations of 4000-5800 ft.; August through September.

COLLECTIONS EXAMINED: **OREGON**: **Clackamas Co**.-Mt. Hood, McNeil Point trail, J. Lindgren (Trappe 8206 in OSC); **Hood River Co**.-Mt. Hood, Tilly Jane Forest Camp, T. Hongo (Trappe 5056 in OSC). **Jefferson Co**.-Mt. Jefferson Wilderness Area, Shirley Lake, J. Trappe 5900 (OSC), Cabot Lake trail, J. Trappe 5896 (OSC) & Carl Lake, J. Trappe 5902 (OSC). **Lane Co**.-McKenzie Drainage, English Mtn., S. Berch (Trappe 7505 in OSC); Three Sisters Wilderness Area, Obsidian trail, D. Luoma 818 (OSC) and S. M. Miller 977 (OSC). **WASHINGTON**: **Chelan Co**.-Lyman Lake, E. Cázares and J. Trappe (Trappe 10412 & 10439 in OSC), E. Cázares (Trappe 10614 in OSC). **King Co**.-Snoqualmie Pass, D. E. Stuntz [Zeller 8272 (NY, holotype of *Truncocolumella rubra*)]. **Skamania Co**.-Indian Heaven, Tombstone Lake, J. Lindgren (Trappe 9018 in OSC). **Whatcom Co**.-4 mi. N. of Copper Lake, J. Trappe 674 (OSC); Hannegan Pass, A. H. Smith #16218 (MICH, OSC); Upper Chilliwack River, J. Trappe 675 (OSC).

DISCUSSION

Originally described as a *Truncocolumella,* this species is actually intermediate between *Gastroboletus* and *Truncocolumella.* The stipe-columella is reduced more than usual for *Gastroboletus* spp. (Thiers & Trappe, **1969**, Thiers, **1989**) but still shows stipe-like characteristics and, when percurrent, is covered with a boletoid epicutis [the two collections available to Smith & Singer (**1959**) evidently had no specimens with a percurrent columella]. The gleba is decidedly tubular in youth, the "mouths" of the outermost locules being stuffed in the manner of many *Boletus* spp. The overall color and bluing reactions are boletoid.

The only other described *Truncolumella, T. citrina* Zeller, the type species for the genus, appears essentially as a *Rhizopogon* with a dendroid columella and bears no macroscopic resemblance to boletes. We suspect it is derived from the genus *Suillus,* whereas *G. ruber* is clearly derived from *Boletus.* Indeed, it so strongly resembles the pileate *Gastroboletus turbinatus*

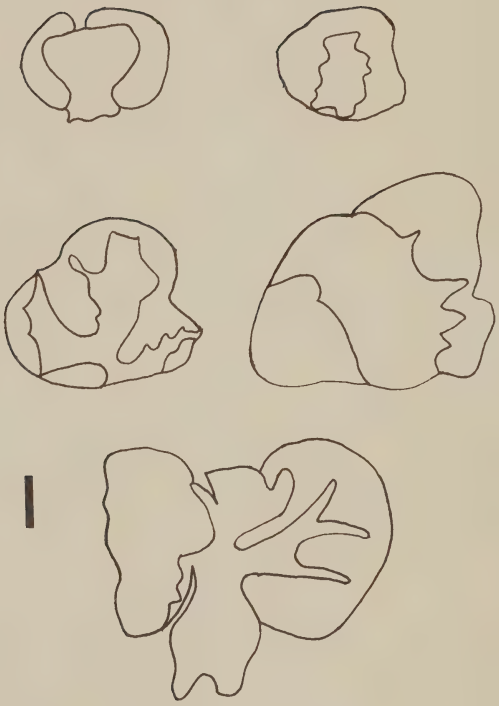


Fig. 5. Diagrammatic cross sections of basidiomata of ***G. ruber***, showing columellae and surrounding glebae. Bar=1 cm.

(Snell) Smith & Singer in microscopic features that we are tempted to regard it as a direct descendent from that species. Both relate directly to *Boletus* sect. *subtomentosi sensu* Thiers.

Until now, *G. ruber* was reported only from two collections in northern Washington (Smith & Singer, **1959**). Apparently confined to the Cascade Mountains, its range is now extended some 400 km south to Lane County, Oregon. We are pleased to note that the first Oregon specimens were found by Prof. Tsuguo Hongo of Shiga University, Japan, when he and Trappe were collecting at Mt. Hood in 1977. Prof. Hongo discovered this exciting find while Trappe was finishing his lunch!

ACKNOWLEDGMENTS

This study was supported by National Science Foundation Grant BSR-8717427 and the U. S. Forest Service, PNW Research Station. Drs. Harry Thiers and Michael Castellano reviewed the manuscript and offered many helpful suggestions. Personnel of the U. S. Forest Service, Wenatchee National Forest, Chelan Ranger District, encouraged and facilitated our field work. SEM photomicrographs were prepared by Dr. Al Soeldner. The senior author thanks "Consejo Nacional de Ciencia y Tecnología" in México for their support.

LITERATURE CITED

Thiers, H. D. 1989. *Gastroboletus* revisited. *Mem. New York Bot. Gard.* **49**:355-359.

Thiers, H. D., and J. M. Trappe. 1969. Studies in the genus *Gastroboletus. Brittonia* **21**:244-254.

Zeller, S. M. 1939. New and noteworthy Gasteromycetes. *Mycologia* **31**:1-32.

Smith, A. H., and R. Singer. 1959. Studies on secotiaceous fungi -IV. *Gastroboletus, Truncocolumella* and *Chamonixia*. *Brittonia* **11**:205-223.

MYCOTAXON

Volume XLII, pp. 347-350 October-December 1991

A NEW FOLIICOLOUS SPECIES IN THE LICHEN GENUS PORINA (PORINACEAE, PYRENULALES) FROM SOUTHERN AFRICA

FRANKLIN A. BRUSSE* & COLIN H. DICKINSON**

*National Botanical Institute, Private Bag X101, Pretoria, 0001 SOUTH AFRICA
** Department of Biology, The University, Newcastle upon Tyne NE1 7RU, ENGLAND*

ABSTRACT

A new foliicolous species in the lichen genus *Porina* Ach. (Porinaceae, Pyrenulales) is described from the Transkei Wild Coast, southern Africa. The new species, *Porina dwesica* Brusse & Dickinson, is illustrated and its relationships are discussed.

NEW SPECIES

Porina dwesica Brusse & Dickinson, *sp. nov.*

Thallus crustosus, foliicola, dispersus, usque ad 1.5 cm diametro, olivaceus vel ferrugineus. *Algae Phycopeltides*, in patellis discretis radiatis crescentes, cellulis rectangularibus, 7 - 18 x 4 - 7 µm. *Perithecia* fulva, singula, prope apicem cum pilis albidis, fragilibus, fimbriata, et annulata, circa 0.3 mm diametris et circa 0.17 mm alta. Involucrellum hyalinum, circa 10 µm crassum, crystallis absunt, K-. Parietes hyalini, circa 10 µm crassi, periclinate prosoplectenchymati. Loculus 135 - 170 x 110 - 120 µm. *Paraphyses* simplices, graciles, 0.8 - 1 µm crassae, flexiles, septatae. *Asci* clavati vel ad apices versus acuminati. Apex truncatus. Parietes hyalini, J-, tenues, sed ad apicem nonnihil incrassati, cum annulo in tinctura "Congo Red" visibiles. *Ascosporae* octonae, hyalinae, 7(-9)-septatae, fusiformes, 22 - 40 x 4 - 5.2 µm. *Pycnidia* fulva, laevia, conica, 100 - 150 µm diametris. *Spermatia* hyalina, ellipsoidea, 2.6 - 3.3 x 0.9 - 1.2 µm. *Conidiomata* et *conidia* non visa.

TYPUS: SOUTH AFRICA, TRANSKEI - **3228** (Butterworth): Dwesa Nature Reserve. 3.7 km from campsite on road to mBashe. About 100 m before nGoma river bridge at road junction. In understorey vegetation of coastal forest. Alt. 30 m (**-BD**). *F. Brusse 5834*, 3. i. 1991 (on *Buxus natalensis* (Oliv.) Hutch. leaves; **PRE**, holo-; **BM**, **LD**, iso-). Figurae 1 et 2.

Thallus crustose, foliicolous, dispersed, up to 1.5 cm across, olive-green to rusty coloured. *Algae Phycopeltis*, in discrete radiate plates (colonies), cells rectangular (in outline) 7 - 18 x 4 - 7 µm. *Perithecia* fawn, one per *Phycopeltis* colony, fringed with a ring of fragile hairs near apex, about 0.3 mm across and about 0.17 mm tall. Involucrellum hyaline, about 10 µm thick, crystals absent, K-. Walls hyaline, about 10 µm thick, periclinally prosoplectenchymatous. Chamber 135 - 170 x 110 - 120 µm. *Paraphyses* simple, slender, 0.8 - 1 µm thick, flexible, septate (best seen in lactophenol Cotton Blue). *Asci* clavate to acuminate towards apex, eight-spored. Apex truncate. Walls hyaline, J-, thin, but somewhat thickened at apex, with ring visible in "Congo Red" stain. *Ascospores* hyaline, 7(-9)-septate, fusiform, thin-walled 22 - 40 x 4 - 5.2 µm. *Pycnidia* fawn, smooth, conical, 100 - 150 µm across. *Spermatia* (microconidia) hyaline, ellipsoid, 2.6 - 3.3 x 0.9 - 1.2 µm. *Conidiomata* and *conidia* (macroconidia) not seen.

This new species was at first mistaken for *Porina epiphylla*, because of the very similar ascospore size range, and perithecial dimensions. On closer inspection, *Porina dwesica* is quite distinct from *P. epiphylla*. In the first place, the thallus is composed of discrete circular colonies of *Phycopeltis*, each of which consists of radiately arranged cells, which are rectangular in outline. Even when the thallus is continuous the limits of the individual *Phycopeltis* colonies are clearly visible under a scanning electron microscope. *Porina dwesica* is therefore primitively associated with its photobiont, because it has not been modified to any great extent. *Porina epiphylla*, on the other hand, has its photobiont, modified so that the radiate arrangement of the free living *Phycopeltis* cells is no longer evident, and they are more irregular in shape as well. The thallus of *P. epiphylla* is continuous and no limits of *Phycopeltis* colonies can be found using a scanning electron microscope. It is interesting to note that although some parts of the thallus of *P. dwesica* have separate *Phycopeltis* plates, these plates are interconnected by hyphae (visible under a scanning electron microscope or by observing a nail varnish transfer under an ordinary light microscope), so that each patch of scattered *Phycopeltis* colonies is best regarded as a single thallus or lichen individual.

The second feature of *Porina dwesica* that distinguishes it from *P. epiphylla* is the perithecium. The upper part of the perithecium of *P. dwesica* is white pilose (figures 1 & 2), very similar to the perithecium of *Porina virescens* (Santesson 1952, fig. 36). In contrast, the upper part of the perithecium of *P. epiphylla* is smooth and non-pilose.

The hyaline thalline wall that covers the perithecium in both species, is K+ brownish-orange in *P. epiphylla* but is K- in *P. dwesica*. This wall gives the perithecium a non-constricted appearance at the base, but there is a cavity within (between the two walls) which gets broader towards the base. An example of a *Porina* that lacks this wall is *P. sphaerocephala* Vain. (Santesson 1952, fig. 40). This additional wall, which hides the constriction at the base, is an advanced character.

Porina dwesica therefore shows a mixture of advanced and primitive characters, suggesting that *P. dwesica* has been more recently lichenized than *P. epiphylla* (based on the degree of photobiont association). Yet the perithecium of *P. dwesica* seems more advanced in evolutionary terms than that of *P. epiphylla*, because the pili around the ostiole in *P. dwesica*, may have some function in aiding ascospore dispersal. This, in turn, suggests that *P. dwesica* has undergone some of its evolution as a non-lichenized fungus, assuming no reversions have taken place. However, reversions are well known in lichens, as most lecanoralean lichen parasites are thought to be delichenized lichens. Thus the ancestor of *P. dwesica* may have had a more highly developed thallus, but has become partially delichenized since.

The third possibility, of course, is that the perithecium has evolved much more rapidly than the degree of association of the lichen fungus with its alga, in this case. *P. sphaerocephala* is an example of a primitive *Porina*, both in thalline and perithecial characters. The photobiont is hardly altered from the free living state, and the perithecium lacks the thalline wall that hides the constriction at the base.

The ascus apex of *P. dwesica* contains a small ring in it, which is visible in Congo Red stain, and is assumed to be chitinous. The walls of the ascus apex do not stain in Lugol's iodine or lactophenol Cotton Blue.

Thus far, this new species is known only from the type locality, Dwesa forest on the Wild Coast of the Transkei, but will no doubt be found to be more widespread when other localities are examined.

ACKNOWLEDGEMENTS

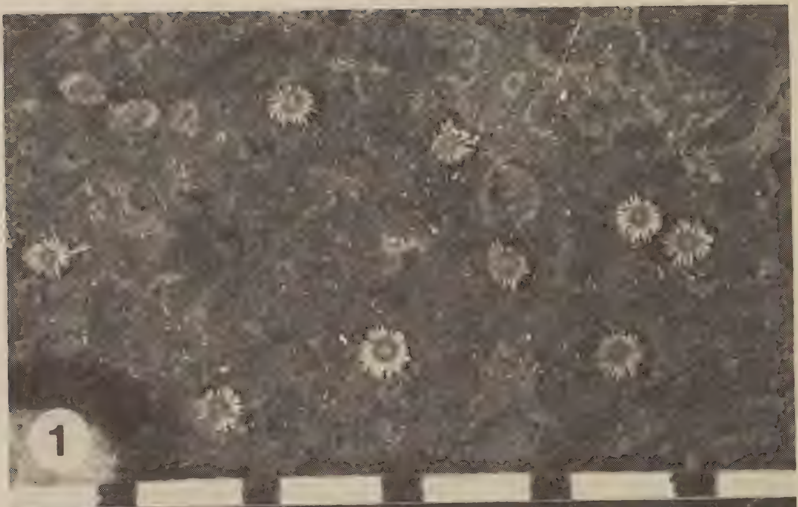
The authors are very grateful to Prof. Rolf Santesson for reviewing this contribution. We are also grateful to Mrs. A.J. Romanowski for the photographs. Thanks are also extended to the Transkei Forestry Department for permits to collect at Dwesa.

LITERATURE CITED

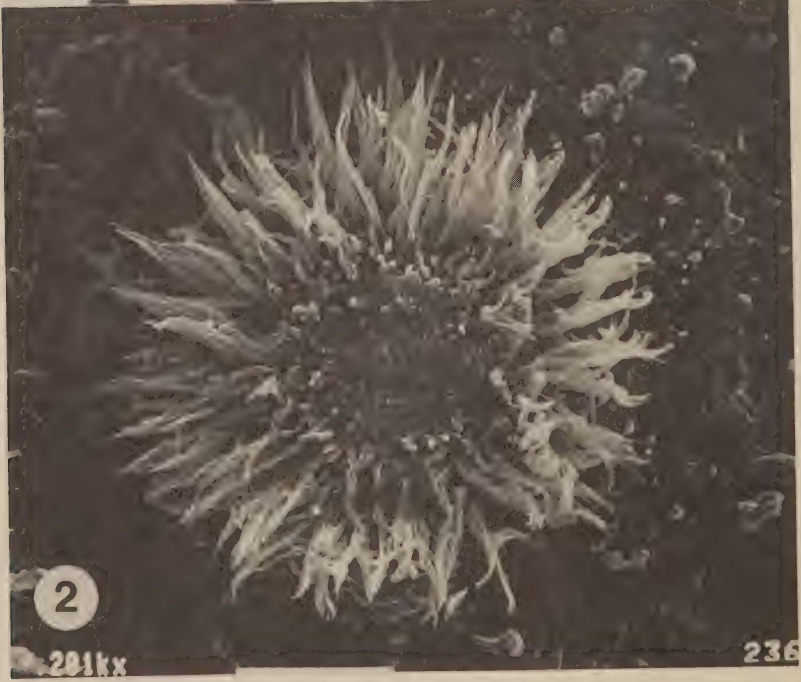
SANTESSON, R. 1952. Foliicolous Lichens 1. A Revision of the Taxonomy of the Obligately Foliicolous, Lichenized Fungi. *Symbolae Botanicae Upsalienses* **12** (1) : 1 - 590.

FIGURE 1. - *Porina dwesica* Brusse & Dickinson, habit photograph. *F. Brusse 5834*, holotype. Scale in mm.

FIGURE 2. - *Porina dwesica* Brusse & Dickinson, scanning electron micrograph of a perithecium, showing pilose upper part. *F. Brusse 5834*, holotype. Bar = 0.1 mm.



1



2

MYCOTAXON

Volume XLII, pp. 351-353 October-December 1991

BUERGENERULA ZELANDICA SP. NOV. ON CAREX SPP. IN NEW ZEALAND

E.H.C. McKENZIE

DSIR Plant Protection
Private Bag, Auckland, New Zealand

During investigations into plant pathogenic fungi of New Zealand, a new species of *Buergenerula* was found to be associated with a distinctive leaf spot of two endemic *Carex* species.

Buergenerula zelandica McKenzie sp. nov. Fig. 1

Mycelium intermum, ex hyphis, hyalinis, ramosis, laevibus, septatis, 3-5 μm crassis. Ascomata solitaria, interma, subglobosa vel globosa, 60-130 μm diam., 95-140 μm alta, ostiolata, papillata; tunica 5-8 μm lata, 2-4 stratis cellularum composita, texturam angularem formans; cellula tenuitunicata, pallide lutea. Asci cylindrici vel clavati, 85-110 x 15-20 μm, breve pendunculati, unitunicati, pariete ascorum apicaliter crasso; corpore apicali, conico, annulari. Ascosporae biseriatae, subhyalinae, medio et infra septatae, ad septa plerumque leviter constrictae, rectae vel leviter curvatae, ovales vel fusiformes, apice obtusae, basi obtusae vel acutae, (28-) 30-37 (-38) μm longae, (8-) 8.5-10 (-11) μm crassae. Conidiophora semi-macronematosa, mononematosa, singula, eramosa, geniculata, laevia, eseptata, hyalina, usque ad 30 μm longa, 5-11 μm crassa. Cellulae conidiogenae polyblasticae, in conidiophoris incorporatae, terminales, sympodiales. Conidia solitaria, acropleurogena, subhyalina, laevia, 1-septata, (39-) 50-65 (-70) μm longa, (8-) 9-10.5 (-11.5) μm lata, recta vel leniter curvata, obclavata, apice obtusa, basi truncata.

In foliis cyperaceae speciei *Carex sinclairii* Boott et *Carex virgata* Boott. Holotypus PDD 44183.

Mycelium immersed, hyaline, branched, smooth, septate, 3-5 μm thick. Ascomata solitary, immersed and developing in cavities in leaf, short papillate, subglobose or globose, 60-130 μm diam., 95-140 μm high, ostiolate; ascomatal wall 2-4 cells thick, uniform in width, 5-8 μm wide; cells forming a textura angularis, thin walled, pale yellowish. Asci cylindrical or clavate, 85-110 x 15-20 μm, short pedunculate, unitunicate, thick walled at apex, with a non-amyloid cone-shaped apical annulus. Ascospores biseriate, subhyaline, pale yellowish in mass, 2-septate, with one median septum and the other in the lower half, usually slightly constricted at septa, oval or fusiform, straight or slightly curved, apex obtuse, base obtuse or acute, (28-) 30-37 (-38) μm long, (8-) 8.5-10 (-11) μm wide. Conidiophores semi-macronematous, mononematous, single, unbranched, geniculate, smooth, aseptate, hyaline, up to 30 μm long, 5-11 μm wide, arising from swollen hyphal cells within the epidermal cells of the host, and perforating the cuticle and outer wall of the epidermal cells. Conidiogenous cells polyblastic, integrated, terminal, sympodial. Conidia solitary, acropleurogenous, subhyaline, pale yellowish in mass, smooth, medianly 1-septate, straight or slightly curved, obclavate, (39-) 50-65 (-70) μm long, (8-) 9-10.5 (-11.5) μm wide, apex obtuse, base truncate.

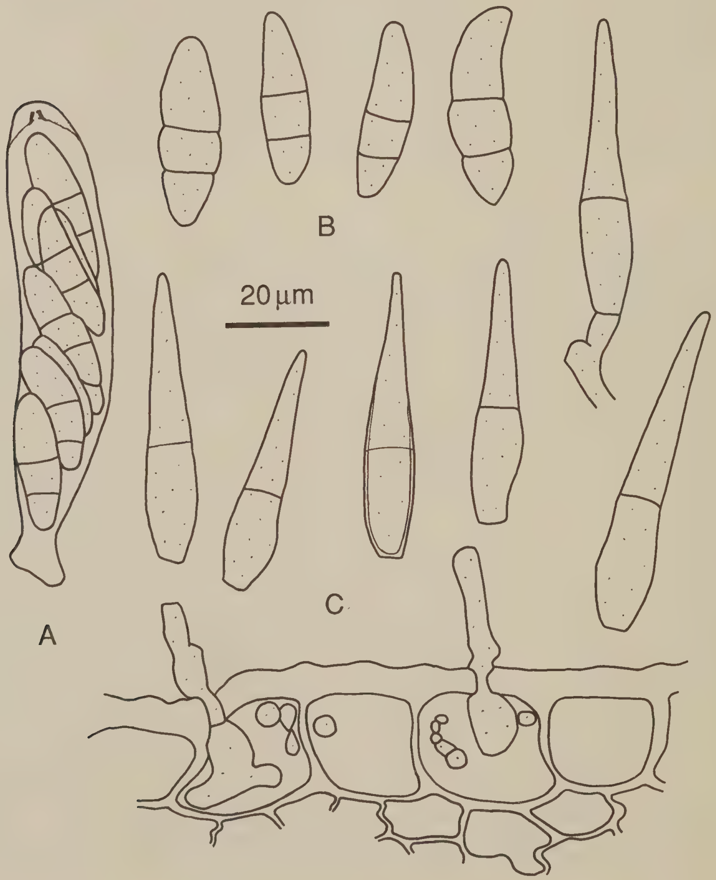


Figure 1 *Buergenerula zelandica*, ascus (a), ascospores (b), conidiophores and conidia (c) from host (PDD 44183, type), mounted in hydrous lactophenol.

On *Carex sinclairii* Boott
Specimen examined: North Island, Taupo, Mt Ruapehu, Silica Springs Track, 24.III.1984, E.H.C. McKenzie (PDD 45209).
On *Carex virgata* Boott
Specimens examined: Chatham Islands: Rekohu, Tennants Lake, 7.III. 1983, E. H. C. McKenzie (PDD 44183 - **holotype**); ibid., 5.III.1983, E. H. C. McKenzie (PDD 44224); Blind Jims Creek, 9.III.1983, E. H. C. McKenzie (PDD 44179, PDD 44180).

Associated with a leaf spot. On *Carex sinclairii* producing pale oval lesions up to 8 mm long, with a distinct border. On *Carex virgata* producing elongate, dark brown lesions, coalescing and covering large parts of the leaf.

Two species of *Buergenerula* are known on *Carex* species; *B. biseptata* (DC. ex Mérat) Speer described from Europe, and *B. caricis* (Sprague) Arx (≡ *Yukonia caricis* Sprague) described from Alaska. Barr (1976) considered these two species to be identical, but von Arx (1977) regarded them as distinct. Conidia have apparently only been recorded on the single Alaskan specimen, although they are present on all five specimens from New Zealand. Paraphyses were not seen in *B. zelandica*, but Barr (1976) described them for *B. biseptata* as being broadly cellular, thin-walled and fragile.

Both ascospores and conidia of *B. zelandica* are somewhat longer than those described by Barr for the European fungus and for the fungus from Alaska. Barr gave ascospore measurements of (19-) 22-27 (-30) x 6-8 (-10) μm, and conidial measurements of (32-) 35-42 (-50) x 9-13 μm. In addition, she described and figured the conidia as obovate and more or less truncate at the apex. This appears to be an error, for both Sprague (1962) and von Arx (1977) described the conidia as obclavate and truncate at the base.

Acknowledgments

I gratefully acknowledge the assistance of Dr G. Kuschel, in preparation of the Latin diagnosis. I thank Dr G.S. Ridley, Botany Department, University of Otago, Dunedin, New Zealand for critical review of this paper.

References

Arx, J. A. von 1977: On *Yukonia caricis* and some other ascomycetes. *Revue de Mycologie 41*: 265-270.
Barr, M. E. 1976: *Buergenerula* and the Physosporellaceae. *Mycologia 68*: 611-621.
Sprague, R. 1962: Some fungi on Western species of Cyperaceae. II. *Research Studies. Washington State University 30(2)*: 45-63.

MYCOTAXON

Volume XLII, pp. 355-386 October-December 1991

PAIRING TESTS WITH SPECIES OF APHYLLOPHORALES (BASIDIOMYCETES) FROM TWO PHYTOGEOGRAPHICALLY ISOLATED AREAS

NILS HALLENBERG
Department of Systematic Botany, University of Göteborg,
Carl Skottsbergs gata 22, S-413 19 Göteborg, Sweden

Abstract. Cultures of 47 species of Aphyllophorales are treated from the Canary Islands and N. E. Turkey. These areas are phytogeographically isolated, and support several endemic higher plants. The degree of genetic isolation among these fungi has been studied by the use of interpairing tests and detailed analysis of fruitbody morphology and character of the substrate. Comparisons have been made with the same species in Europe and Canada. In general, a high similarity was found in the wood-fungus flora between the investigated areas and corresponding forests in Europe. Genetic differentiation was, however, manifested in several species and appeared to be more frequent than among collections of pure European origin. Such differentiation was expressed by partial, heterogenic incompatibility, formation of barriers in compatible matings, differences in fruitbody morphology, and occurrence of new sibling species.

INTRODUCTION

Wood-inhabiting basidiomycetes (Aphyllophorales) were collected during two weeks in March, 1989, in the Canary Islands and three weeks in October, 1989, in N.E. Turkey. Spore-prints were obtained during the field-work and cultures were isolated in the laboratory (Göteborg). In the Canary Islands collecting took place in three areas in the northern parts of Tenerife: Esperanza Mts. (pine forests), Anaga Mountains, and Aqua Mts. near Los Silos (both evergreen *Laurus* forests). Moreover, wood-fungi were also collected in the island Gomera, Garajonay National Park near El Cedro (mixed *Laurus* forest).

In Turkey, collecting took place in mountainous areas, mainly in the vicinity of Sumela monastery, near Trabzon, with pure *Picea orientalis* (L.) Link forests at higher altitudes (collections made up to 1900 m.s.m.) while mixed with deciduous trees (*Alnus, Fagus, Carpinus*) at lower altitudes and in river valleys.

Both these areas are today phytogeographically relatively isolated. The Canary islands Tenerife and Gomera, formed 7 and 12 million years ago, are probably of pure volcanic origin (Aguilar, 1989). A number of the dominating forest-trees (*Laurus azorica* (Seub.) Franco, *Persea indica* Spreng., *Pinus canariensis* Spreng.), now regarded as endemic, were present in the Tertiary flora of S. and W. Europe (Takhtajan, 1969, Bramwell, 1972). In N.E. Turkey, along the northern slopes of the Pontic ranges of mountains, the climate is of an oceanic type with abundant rainfall and no summer drought (Quézel, 1986). The "Pontic" forests formed in this Euxine zone (Zohary, 1973) are phytogeographically isolated by surrounding relatively dry areas. Some of the dominating tree species are endemic to this and adjacent regions (*Picea orientalis, Fagus orientalis* Lipsky). A number of plants here are regarded as Arcto-Tertiary relicts and had a much wider distribution towards the north before the last glaciation (Zohary, 1973).

The fungus flora of the Canary Islands has been fairly well documented thanks to the activities by local mycologists and to the many collecting trips made by others. A check-list has been presented (Beltran Tejera, 1980) and a thesis work on Aphyllophorales fungi has been made at the University of La Laguna (J. L. Rodriguez-Armas). All these results clearly indicate that the wood-fungus flora (Basidiomycetes) mainly consists of species which elsewhere are found in Mediterranean areas or in other parts of Europe. In the Euxine zone of N.E. Turkey only sporadic mycological contributions have been made (Kotlaba, 1976, Niemelä & Uotila, 1977). Judging from these records as well as from results from the present study, the wood-inhabiting basidiomycetes are in common with European areas with similar vegetation.

The purpose of this study is to investigate the degree of genetic isolation by way of intercompatibility tests, between these two areas and Europe and N. America. Detailed studies on the intraspecific variation in fruitbody morphology and in substrate preferences have been made and are based on the specimens used in the tests. The study primarily treats species in the family Corticiaceae but some polypore species are included. The existence of homothallic forms is also reported, as well as individual specimens which are incompatible with other representatives of the same species. A few species brought into culture are not treated here because no further isolates of these particular species were available.

METHODS

Pairing tests were made on malt agar discs (5.5 cm in diam., 1.25 % malt extract) between single-spore (SS) cultures. However, when only a polyspore culture was available from one specimen, di-mon tests were carried out. In some pairings partial incompatibility has been found. Such incompatibility has been regarded as heterogenic (Esser & Blaich, 1973) when it was found that the noted incompatibility is the effect of other genetical factors than the sharing of common mating type factors. Such partial incompatibility is described in detail, and the following symbols are then used:

+ = complete compatibility (formation of secondary mycelium, indicated by the presence of clamps).

(+)= Restricted mating ability. Clamps rather rare and only found in a narrow confrontation zone.

- = Incompatibility, frequently manifested by the formation of a distinct barrier.

Prior to intercompatibility matings, polarity tests were carried out. Compatible mating types from the different specimens were used in the tests. For further details in performance of the tests, see Hallenberg (1988).

Origin of cultures used in the tests is presented under each species (below). Since the Turkish collections were made in the Trabzon area, this location is not repeated under each species. Instead, the type of vegetation is given. For collections from this area *"Picea"* means *P. orientalis*, "*Fagus*" means *F. orientalis*, and *"Alnus"* means *A. glutinosa* (L.) Gaertner ssp. *barbata* (C.A. Meyer) Yalt. Collecting and determinations were made by the author if not otherwise stated in the lists of material tested. For authoritative descriptions of fruitbodies, see below under each species treated.

RESULTS FROM PAIRING TESTS

Athelia decipiens (Höhn. & Litsch.) John Erikss.
Description: Eriksson & Ryvarden (1973).
Material tested:
GB 2214/ *Picea*/ Turkey, in *Picea* forest with scattered *Fagus*.
GB 1494/ Coniferous wood/ Romania, Suceava.
GB 1691/ *Picea*/ Finland, North Häme.
GB 1762/ *Acer*/ Sweden, Dalsland.
GB 2186/ *Betula*/ Estonia, Lahemaa Nat. Park.

Partial compatibility was found between GB 2214 and the other specimens according to the following (heterogenic incompatibility indicated):

	GB-1494-2	GB-1494-3	GB-1691-1	GB-1691-3	GB-1762-2	GB-1762-8	GB-2186-1	GB-2186-2
GB-2214-1	(+)	-	-	-	-	-		
GB-2214-7	-	-			+	-	+	+
GB-2214-3	+	+	+	+	+	+		

From polarity tests for GB 2214 was found that, SS-1 and 7 belonged to the same mating type which was compatible with SS-3. Compatibility between the European specimens has been reported earlier (Hallenberg, 1988).

No differences in fruitbody morphology were found between the tested specimens. All fruitbodies were found on naked wood. In the specimens where coniferous wood was noted as substrate, the wood was moderately brown-rotted (GB 1494, GB 1691) or strongly brown-rotted (GB 2214), while the deciduous wood was white-rotted (GB 1762, GB 2186). *Athelia decipiens* is most probably not involved in the decay.

Brevicellicium olivascens (Bres.) Larss. & Hjortst.
Description: Hjortstam et al. (1988).
Material:
GB 2267/ Deciduous wood/ Turkey, in mixed *Alnus* forest on a slope.

All 10 isolated SS-cultures were clamped. SS-cultures from seven other specimens (Nordic countries, Canada) have earlier also been found to be constantly clamped, thus the species can be regarded as homothallic.

Ceriporiopsis pannocincta (Rom.) Gilb. & Ryv.
Syn.: *Polyporus pannocinctus* Rom.
Description: Gilbertson & Ryvarden (1986).
Material tested:
GB 2109/ Deciduous wood/ Tenerife, Aqua Mts.
GB 2164/ Deciduous wood/ Tenerife, Aqua Mts.
GB 560/ *Acer*/ Canada, Quebec, Ottawa area.

Compatibility was shown between GB 2109 and GB 560. The second culture from Tenerife (GB 2164) was incompatible with the other two. No morphological differences were observed between the pertinent fruitbodies.

David (1972) showed that a culture from N. America was compatible with one from France. She also reported on culture characters and found that *Gloeoporus pannocinctus* had a heterocytic nuclear behaviour and was tetrapolar. Domanski (1970), however, reported the species to be bipolar. Also in this study only two compatible mating types were found among 10 isolated single-spore cultures (GB 2109). In GB 2164 it was not possible to evaluate the polarity patterns because of too few available SS-cultures.

Chondrostereum purpureum (Fr.) Pouz.
Description: Eriksson & Ryvarden (1973).
Material tested:
GB 2200/ *Carpinus*/ Turkey, in mixed *Alnus* forest on a slope.
GB 777/ On bark/ Canada, Quebec, Cantley.
GB 1267/ *Betula*/ Sweden, Småland.
GB 2011/ *Alnus*/ Canada, British Columbia, Vancouver Island.

Compatibility between tested specimens except for pairings between GB 1267 and GB 777, where partial compatibility was recorded:

GB 1267-SS-3,10 x GB 777-SS-1,2 = +
GB 1267-SS-2,9 x GB 777-SS-1,2 = -

In polarity tests for GB 1267 it was found that SS-3 mated SS-9 and SS-2 mated SS-10 (tetrapolarity). Heterogenic incompatibility is indicated. The specimens agree very well with each other in their fruitbody morphology. Robak (1942) has earlier shown compatibility between specimens from Norway and Canada.

Cylindrobasidium evolvens (Fr.) Jül.
Description: Eriksson & Ryvarden (1976).
Material tested:
GB 2208/ *Alnus*/ Turkey, in *Alnus* forest by a river.
GB 1031/ Coniferous wood/ Romania, Alba.
GB 1268/ *Betula*/ Sweden, Småland.
GB 1800/ Deciduous wood/ Spain, Lerida.
GB 2319/ *Alnus*/ USSR, Sverdlovsk area (Yamal)/ Coll. Mukhin.

Compatibility between the tested specimens except for pairings with the Turkish collection (GB 2208):

	GB-1031-3	GB-1031-4	GB-1268-4	GB-1268-7	GB-1800-1	GB-1800-3	GB-2319-1	GB-2319-2
GB-2208-2	(+)	(+)	+	+	+	+	+	+
GB-2208-8	-	-	(+)	+	-	-		
GB-2208-9	-	-	+	+	(+)	+	-	+

In polarity tests for GB 2208, SS-2 was compatible with SS-8,9. The partial compatibility is obviously of a heterogenic nature. No morphological differences were observed between fruitbodies of the tested specimens. Intercompatibility tests for this species were earlier reported by Hallenberg (1984 a).

Dacryobolus sudans (Fr.) Fr.
Description: Eriksson & Ryvarden (1975).
Material tested:
Group 1. GB 742/ Coniferous wood/ Canada, Ontario, Algonquin.
GB 1064/ *Picea*/ Romania, Suceava.
GB 1840/ *Pinus*/ France, Pyrenees Orientales.
GB 2167/ Deciduous wood/ Tenerife, Esperanza Mts.
Group 2. GB 1997/ *Tsuga*/ Canada, B.C., Vancouver Isl.
GB 2006/ *Tsuga*/ Canada, B.C., Vancouver Isl.
Group 3. GB 2252/ *Alnus*/ Turkey, in *Picea* forest with scattered *Fagus*.

Compatibility within group 1 and 2, incompatibility between the three groups. Results from compatibility tests has earlier been reported but then only specimens belonging to group 1 were available (Hallenberg, 1985 b).

Characteristics of tested specimens:

Group 1. In fruitbody morphology, there is a variation among the specimens concerning the size of aculei, their density, and in the differentiation of context. In specimens with relatively thick fruitbodies (up to 0.2 mm when dried), there is a gelatinous middle layer, composed of densely united, thin-walled hyphae. In thin specimens the gelatinous layer is very thin or lacking. The spores are cylindrical to allantoid, 6.5-7.5 x 1.5-1.8 µm.This group is geographically widely distributed (Fig. 1). Most specimens were collected on naked wood (GB 1340 on bark).

Group 2. The two specimens have well developed fruitbodies of relatively big size (up to 10 cm across). A distinct gelatinous middle layer is developed in

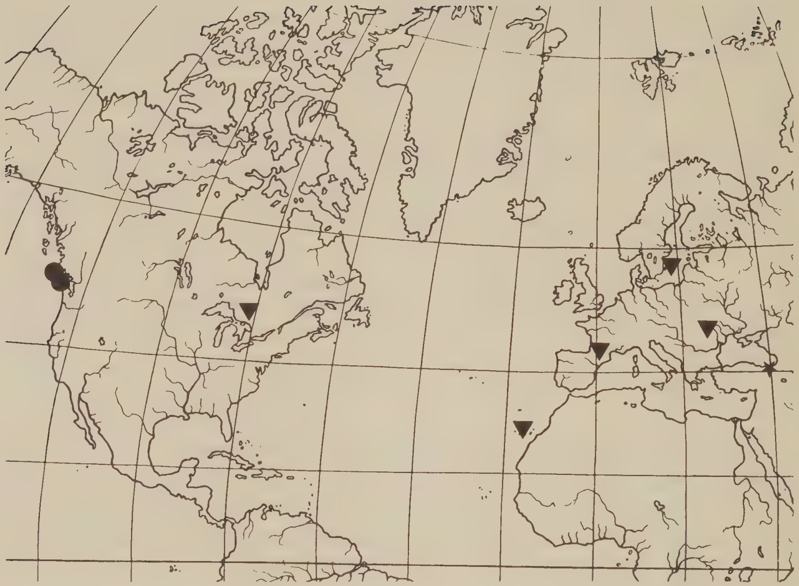


Fig. 1. Distribution of sibling species in *Dacryobolus sudans.* ▼ = group 1, ● = group 2, ★ = group 3.

the fruitbodies, the hymenial surface is densely aculeate (as in some specimens in group 1), individual aculei are of variable size. The most constant character which separates this group from both group 1 and group 3 specimens, is the spore size. They are in group 2 somewhat smaller, 5.5-6.5 x 1-1.3 µm. The two specimens were both collected on the bark of dead but leaning trees of Tsuga, on the W. coast of Vancouver Island, Canada.

Group 3. The Turkish collection was the only one found on deciduous wood. The fruitbody is thin with a weakly developed gelatinous middle layer, the hymenium is densely aculeate and individual aculei are smaller and more rounded than in the other two groups. Spores were intermediate in size: 6-7 x 1.3-1.5 µm.

Fomitopsis rosea (Fr.) Karst.
Description: Gilbertson & Ryvarden (1986).
Material tested:
GB 2224/ *Picea*/ Turkey, in pure *Picea* forest.
GB 133/ *Picea*/ Sweden, Dalarna.

The tested specimens were compatible. No morphological differences found between the fruitbodies. Intercompatibility between representatives from N. America was shown by Mounce & Macrae (1937).

Gloeocystidiellum clavuligerum (Höhn. & Litsch.) Nakas.
Description: Nakasone (1982), Hallenberg (1984 a).
Material tested:
GB 2159/ Deciduous wood/ Tenerife, Aqua Mts.
GB 2238/ *Alnus*/ Turkey, in mixed *Alnus* forest on a slope.
GB 676/ *Alnus*/ Canada, B.C., Vancouver Isl.
GB 1039/ Deciduous wood/ Romania, Bihor.
GB 2248/ *Tilia*/ France, Landes/ Coll. Gilles.

Cultures of *G. porosum* (Berk. & Curt.) Donk used in the test:
GB 587/ *Alnus*/ Canada, Quebec, Ottawa area.
GB 1018/ *Fagus*/ Romania, Suceava.

The specimen from Tenerife (GB 2159) was incompatible with all specimens of *G. clavuligerum* and *G. porosum*. The Turkish collection (GB 2238) was compatible with GB 676, GB 1039, and GB 2248. The two species are both widely distributed and compatibility has been shown between a number of specimens from Europe and Canada (Hallenberg 1984 a, 1988, Fig. 2). The differences between *G. clavuligerum* and *G. porosum* were discussed by Hallenberg (1984 a) and Nakasone (1982) and concern in principal the sulfocystidia and the spores. In *G. clavuligerum* the sulfocystidia are mostly terminal,

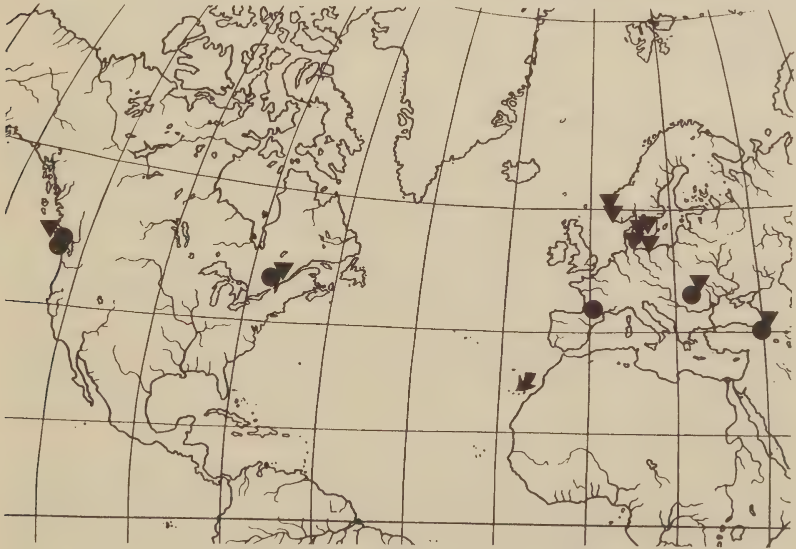


Fig. 2. Distribution of compatible specimens in *Gloeocystidiellum clavuligerum - G. porosum*.
● = *G. clavuligerum*, ▼ = *G. porosum* , ▼= GB 2159.

ventricose, up to 100 x 16 µm in size (Nakasone, 1982); spores 4-5 x 2.8-3.5 µm (Hallenberg, 1984 a). In *G. porosum* the sulfocystidia are sinuous, frequently lateral, up to 150 µm long; the spores are somewhat longer (4.5-7 x 2.5-3.5 µm).

The specimen from Tenerife (GB 2159) seems to be close to *G. clavuligerum* as the sulfocystidia are ventricose and rather small (25-55 x 8-15 µm), occurring both in the context and in the hymenium and not penetrating through the whole of the fruitbody as in *G. porosum*. The spores are slightly larger than in *G. clavuligerum*, 4.5-5.3 x 3-3.5 µm.

The Turkish collection (GB 2238) was in accordance with the other representatives of *G. clavuligerum*.

Tetrapolarity has been indicated for GB 2159 as well as for GB 2238 and GB 2248 (*G. clavuligerum*) and *G. porosum* (Boidin & Lanquetin, 1984).

Gloeocystidiellum porosum (Berk. & Curt.) Donk
Description: Eriksson & Ryvarden (1975).
Material tested:
GB 2246/ *Alnus*/ Turkey, in mixed *Alnus* forest on a slope.
GB 1916/ *Fagus*/ Denmark, Jylland.
GB 1939/ *Salix*/ Denmark, Jylland.

Partial compatibility was recorded between representatives of three mating types in GB 2246 and four mating types in GB 1939:

	GB 1939-1	GB 1939-2	GB 1939-5	GB 1939-6
GB 2246-1	+	+	-	-
GB 2246-3	+	+	-	-
GB 2246-9	+	+	+	+

A distinct barrier was formed in combinations between GB 2246 and GB 1939-SS-1, but clamps were found in all parts of the mated mycelia. Between GB 2246 and representatives of the four mating types in GB 1916 there was a complete compatibility and no barriers were formed.

No noticeable morphological differences observed between the fruitbodies but the spores in the Turkish collection (4.5-5.5 x 2.8-3.3 µm) are small although clearly within the limits of *G. porosum* (see above, under *G. clavuligerum*).

Gloeodontia columbiensis Burt ex Burds. & Lomb.
Description: Burdsall & Lombard (1976).
Material:
GB 2133/ Deciduous wood/ Tenerife, Aqua Mts.
GB 2263/ Deciduous wood/ Turkey, in mixed *Picea forest*.

In GB 2133, all 10 isolated single-spore cultures were clamped, thus this specimen is presumed to be homothallic. However, in GB 2263 heterothallism was found. This agrees with the results by Burdsall & Lombard (1976), who reported that the species in North America was heterothallic and bipolar.

G. columbiensis has rarely been found outside N. America. In Europe, it has been found in Switzerland on *Tilia* (E. Martini), while Hallenberg (1981) reported it from N. Iran.

Hyphoderma cremeoalbum (Höhn. & Litsch.) Jül.
Description: Eriksson & Ryvarden (1975).
Material tested:
GB 2270/ *Picea*/ Turkey, in *Picea* forest with scattered *Fagus*.
GB 456/ *Picea*/ Sweden, Lycksele Lappmark/ Coll. Larsson.
GB 885/ Coniferous wood/ Sweden, Lycksele Lappm./ Coll. Larsson.
GB 1549/ *Fagus*/ Romania, Neamt.
GB 1773/ *Picea*/ Norway, Hedmark.

Complete compatibility was found between GB 2270, GB 456 and GB 885, partial compatibility with GB 1549 and GB 1773:

	GB 456-10,12	GB 885-8	GB 885-13	GB 1549-1,2	GB 1773-1	GB 1773-2
GB 2270-1,3	+	+	+	+	-	(+)
GB 1549-1	-	-	-			
GB 1549-2	-	-	(+)			

In fruitbody morphology all tested specimens were very similar and all were collected on much decayed, white-rotted wood. However, it is noteworthy that GB 1549 was collected on *Fagus* in a pure *Fagus* forest, while the other specimens were found on coniferous wood. In N. Europe, *H. cremeoalbum* has a distinct preference for coniferous wood.

Hyphoderma medioburiense (Burt) Donk
Description: Eriksson & Ryvarden (1975).
Material:
GB 2106/ Deciduous wood/ Tenerife, Aqua Mts.
GB 2113/ Deciduous wood/ Tenerife, Anaga Mts.
GB 2132/ Deciduous wood/ Tenerife, Aqua Mts.

Single-spore cultures from all three specimens were clamped immediately after isolation (10 isolated cultures from each specimen). Our culture collection has four additional specimens of this species, from various parts of Europe, and the single-spore cultures eventually become clamped. *H. medioburiense* is thus regarded as homothallic, although the haploid state persisted for 2 years in some stored single-spore cultures.

Hyphoderma praetermissum (Karst.) Erikss. & Strid

Several cultures of this species have been isolated from the Canary Islands and from Turkey. Because of the many sibling species found in this species complex, the results will be treated more thoroughly in a separate paper.

Hyphoderma puberum (Fr.) Wallr.

Description: Eriksson & Ryvarden (1975).
Material tested:
GB 2245/ Deciduous wood/ Turkey, in mixed *Picea* forest.
GB 1951/ *Picea*/ Denmark, Jylland.
GB 1959/ *Quercus*/ Denmark, Jylland.

Complete compatibility was found between the tested specimens. No noticeable morphological differences were observed between the fruitbodies but GB 2245 was collected on a piece of bark, while the Danish collections were growing on much decayed, white-rotted wood.

Altogether, now 17 specimens belong to one compatibility group in this species. They originate from the Nordic countries, Turkey and Canada, and were collected on *Picea*, *Pinus*, *Alnus*, *Betula*, *Corylus*, *Fagus*, and *Quercus*. Earlier, records on intercompatibility were reported by Hallenberg (1984 a).

Hyphoderma roseocremeum (Bres.) Donk

Description: Eriksson & Ryvarden (1975).
Material tested:
GB 2107/ Deciduous wood/ Gomera, Garajonay Nat. Park.
GB 2272/ Deciduous wood/ Turkey, in mixed *Picea* forest.
GB 1796/ *Fagus*/ Spain, Huesca.
GB 1948/ *Fagus*/ Denmark, Jylland.

Compatibility between the tested specimens was shown. No differences in fruitbody morphology were noticed between GB 2107, GB 2272 and European collections. In Hallenberg (1984 a) compatibility was shown between a number of cultures from Canada and Europe. In this study it was found that Canadian specimens differed from European ones by having slightly bigger spores and by the preference for coniferous wood as substrate instead of deciduous wood. The number of compatible specimens from Europe has, moreover, accumulated in recent years and now includes 16 specimens.

Hyphoderma transiens (Bres.) Parm.

Description: Telleria (1980), Eriksson & Ryvarden (1975, p 473, as *Odontia subalbicans* sensu Bourdot).
Material tested:
GB 2229/ Deciduous wood/ Turkey, in mixed *Alnus* forest on a slope.
GB 1496/ *Quercus*/ Romania, Iasi.
GB 1990/ *Quercus*/ Switzerland, Bolle di Magadino/ Coll. Martini & Zenone.

Complete compatibility exists between GB 1496 and GB 1990, while partial compatibility was found in combinations with GB 2229.

	GB 1496-1	GB 1496-2	GB 1990-1	GB 1990-2	GB 1990-4
GB 2229-1	-	-	-	+	-
GB 2229-3	(+)	(+)	(+)	+	(+)
GB 2229-4	+	+	+	+	+
GB 2229-6	(+)	(+)	+	+	+

In GB 1990, SS-1 and SS-4 represent the same mating type, while SS-2 is the compatible one. Incompatible matings were associated with the formation of distinct barriers. Because of the high degree of genetical isolation of the Turkish collection it seems probably to explain the negative results as heterogenic incompatibility.

A comparison between the different fruitbodies reveals some differences:

	GB 2229	*GB 1496, GB 1990*
Spore size:	8-10 x 3-3.8 µm	10-13 x 3.5-4.5 µm
Cystidia:	Frequent	Scattered - rare
Hymenophore:	Minute, conical aculei	Almost 1 mm long aculei, robust, cylindrical

Hyphodontia nespori (Bres.) Erikss. & Hjortst.
Description: Eriksson & Ryvarden (1976).
Material tested:
GB 2163/ Deciduous wood/ Tenerife, Anaga Mts.
GB 2259/ *Picea*/ Turkey, in pure *Picea* forest.
GB 2261/ *Alnus*/ Turkey, in *Alnus* forest by a river.
GB 2264/ *Fagus*/ Turkey, in mixed *Picea* forest.
GB 2266/ *Alnus*/ Turkey, in *Alnus* forest by a river.
GB 1530/ *Abies*/ Romania, Neamt.
GB 1968/ *Picea*/ Denmark, Jylland.
GB 2039/ *Picea*/ Denmark, Jylland.

The tested specimens were compatible and they agree well with each other in their fruitbody morphology. All specimens were found on white-rotted wood. Three additional cultures from Denmark and Romania also belong to this compatibility group.

The most common substrate for *H. nespori* in Europe is coniferous wood and the species is very common in *Picea* plantations in Denmark.

Hyphodontia quercina (Fr.) John Erikss.
Description: Eriksson & Ryvarden (1976).
Material tested:
GB 2249/ *Carpinus*/ Turkey.
GB 2254/ *Deciduous wood*/ Turkey.
GB 2255/ Deciduous wood/ Turkey. All Turkish specimens were collected in mixed *Picea* forest at Sumela monastery, near Trabzon.
GB 1284/ *Carpinus*/ Sweden, Skåne.
GB 2013/ *Alnus*/ Canada, B.C., Vancouver Isl.

Complete compatibility was found between the tested specimens. In external morphology the specimens are variable, depending on degree of development. In their micromorphology no differences were observed. All specimens were collected on white-rotted branches, which were decayed to varying degrees.

Hyphodontia subalutacea (Karst.) John Erikss.
Description: Eriksson & Ryvarden (1976).
Material tested:
Group 1. GB 1433/ Coniferous wood/ Norway, Akershus.
Group 2. GB 2158/ Deciduous wood/ Gomera, Garajonay Nat. Park.
GB 1208/ *Betula*/ Norway, Hordaland.
GB 1522/ *Fagus*/ Romania, Brasov.
GB 1961/ Deciduous wood/ Denmark, Jylland.
Group 5. GB 2131/ *Pinus*/ Tenerife, Esperanza Mts.
GB 1834/ *Pinus*/ France, Pyrenees Orientales.
Group 6. GB 2258/ *Picea*/ Turkey, in pure *Picea* forest.
GB 1838/ *Pinus*/ Spain, Huesca.

The complex situation in *H. subalutacea* with a number of sibling species has been reported earlier (Hallenberg, 1988) and group designations refer to that study. Additional cultures belonging to group 1 and 2 are also listed there. Compatibility has been recorded within each group, incompatibility between them. An exception was a culture from Canada belonging to group 1 and which also was compatible with representatives of group 2 (Hallenberg, 1984 a). The hitherto investigated specimens are mapped (Fig. 3). There are only minute morphological differences between representatives of the different groups, while the selection for certain substrates seems to be much more important in the speciation processes which has resulted in this kind of genetical isolation.

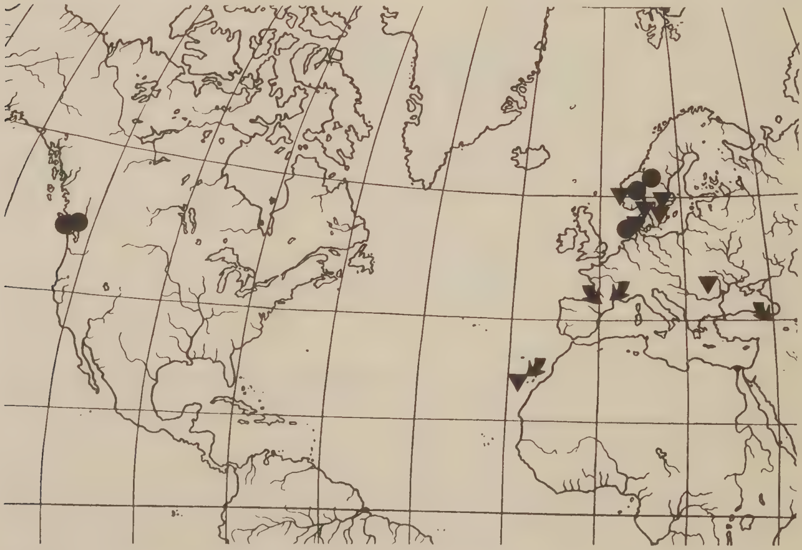


Fig. 3. Distribution of sibling species in *Hyphodontia subalutacea*. ● = group 1, ▼ = group 2, ◣ = group 5, ◢ = group 6.

The two specimens cultured from the Canary Islands belonged to group 2 and 5. It is interesting to note that group 2 seems to be very widespread - both geographically and ecologically. One of the representatives (GB 1208) was collected in a subalpine birch forest in Norway, another one in a fertile *Ulmus* swamp in Sweden (GB 335), and now also from Gomera.

Group 5 and 6 were earlier only represented by single specimens.

Hypochnicium eichleri (Bres.) Erikss. & Ryv.
Description: Eriksson & Ryvarden (1976).
Material tested:
GB 2151/ Deciduous wood/ Gomera, Garajonay Nat. Park.
GB 1362/ *Fagus*/ Sweden, Dalsland.
GB 1794/ *Pinus*/ France, Landes.
GB 1921/ Deciduous wood/ Denmark, Jylland.
GB 1772/ *Pinus*/ Sweden, Dalsland.

GB 2151 was incompatible with all other cultures mentioned here. GB 1362, GB 1794, and GB 1921 are intercompatible and belong to a bigger compatibility group, widely distributed in Europe (Hallenberg, 1988). The fruitbodies of representatives of this group agree closely with the type of *H. eichleri*.

Also GB 1772 is incompatible with the representatives mentioned here but partially compatible with a specimen from the Pyrenees, growing on *Pinus* (GB 1865).

The results from pairing tests in this aggregate are indeed complex. In fruitbody morphology all are very similar. Only the spore sizes differ minutely. In the widespread, central group mentioned above, as well as in GB 1772, the spores are subglobose, 7-8 x 5.5-7 µm. In GB 1865 they are slightly longer (8.5-9 x 6-6.5 µm) and somewhat differently shaped (ellipsoid - ovoid), while they are slightly smaller in GB 2151 (6.5-7 x 5-6 µm) and broadly ellipsoid.

Specimens with bigger spores (8-10.5 x 6-7 µm, single spores even bigger) which are ellipsoid to ovoid have usually been labelled *H. albostramineum* (Bres.) Hallenb. However, isolated cultures of such specimens have been homothallic (Hallenberg, 1985 a).

Specimens with spores smaller than in *H. eichleri* have frequently been filed under *H. punctulatum* (Cooke) John Erikss. but the type specimen of the latter species has been found to be in accordance with *H. eichleri* (Hallenberg & Hjortstam, 1989). Only the substrate separates it clearly from the latter species (type of *H. punctulatum* on soil, type of *H. eichleri* on wood).

In many investigated species complexes it has been found that the substrate may be a differentiating factor between the individual siblings. It is reasonable to beleive that the situation is the same in *H. eichleri* complex, even if no cultures exist from specimens growing on earth. Consequently, *H. eichleri* seems to be a proper name for specimens growing wood with subglobose spores, 7-8 µm long, while *H. punctulatum* should be used for such speimens growing on soil. The use of the name *H. punctulatum* for more small-spored specimens does not seem to be justified and the taxonomy for them is at the moment not settled.

Hypochnicium polonense (Bres.) Strid
Description: Eriksson & Ryvarden (1976).
Material tested:
GB 2262/ *Fagus*/ Turkey, in *Picea* forest with scattered *Fagus*.
GB 1536/ Deciduous wood/ Romania, Brasov, in pure *Fagus* forest.
GB 1538/ Deciduous wood/ Romania, Iasi, in *Quercus* -, *Carpinus* forest.

These specimens were found to be compatible but incompatible with a second group:
GB 809/ Deciduous wood/ Canada, Ontario, Ottawa area.
GB 942/ *Ulmus*/ Norway, N. Tröndelag.

Compatibility was earlier shown for GB 809 and GB 942 (Hallenberg, 1985 b). No morphological differences were observed between the fruitbodies. It has not even been possible to find out any differences between the pertaining substrates. All specimens were found on naked, white-rotted wood, lots of blue-stain fungi were present close to the surface, and remnants from burnt wood were found on most of the tested specimens.

Junghuhnia nitida (Fr.) Ryv.
Description: Ryvarden (1978).
Material tested:
GB 2129/ Deciduous wood/ Tenerife, Anaga Mts.
GB 1520/ *Fagus*/ Romania, Iasi.

The two specimens were compatible. No morphological differences were noted in their fruitbody morphology.

Mycoacia uda (Fr.) Donk
Description: Eriksson & Ryvarden (1976).
Material tested:
GB 2220/ *Alnus*/ Turkey, in mixed *Alnus* forest on a slope.
GB 2243/ *Alnus*/ Turkey, in *Alnus* forest by a river.
GB 1326/ *Ulmus*/ Sweden, Västergötland.
GB 1825/ *Fagus*/ Spain, Navarra.
GB 2015/ Deciduous wood/ Canada, B.C., Vancouver Isl.

Compatibility between the tested specimens was found. Altogether, 10 specimens have been found to belong to the same compatibility group, while no sibling species have been detected hitherto. However, some cases of partial (homogenic and heterogenic) incompatibility have been reported earlier (Hallenberg, 1985 b).

From microscope observations no differences between the specimens have been found but in external features there is noticeable variation, especially in the teeth of the hymenophores, which vary from long (up to 2 mm) and slender to short and blunt. The teeth may densely cover the hymenial surface or be scattered. The yellowish pigment which usually is regarded as diagnostic for the species may also vary considerably.

Peniophora cinerea (Fr.) Cke.

Several cultures have been isolated of this species from Turkey. Results from pairing tests with these will, however, be treated in a separate paper.

Peniophora incarnata (Fr.) Karst.
Description: Eriksson et al (1978).
Material tested:
GB 2199/ Deciduous wood/ Turkey, in mixed *Picea* forest.
GB 2201/ *Alnus*/ Turkey, in *Alnus* forest by a river.
GB 2277/ *Alnus*/ Turkey, in mixed *Alnus* forest on a slope.
GB 1689/ *Populus*/ Finland, North Häme.
GB 1909/ *Corylus*/ Denmark, Jylland.
GB 2100/ *Rosa*/ Sweden, Skåne.

All specimens were found to be compatible. At present, 14 specimens have been found to belong to a single compatibility group and no sibling species have been detected (see also Hallenberg, 1988). In fruitbody morphology, all specimens conform well with the description given in Eriksson et al. (1978). However, there is a certain variation which in most cases is attributable to different degree of development. The colour, which in some way reflects the microstructure, may be whitish - orange - ochraceous, even if the orange colour is the one most frequently met with. Gloeocystidia (sulfocystidia) are always numerous. In some specimens (like GB 2100) there is a distinct basal zone with densely packed gloeocystidia next to the thin subiculum. More frequently gloeocystidia are found to penetrate the whole fruitbody and even reach the hymenial level. Frequency of metuloids varies considerably and being from rare (GB 2100) to abundant (Turkish collections).

Peniophora lycii (Pers.) Höhn. & Litsch.
Description: Eriksson et al. (1978).
Material tested:
GB 2104/ Deciduous wood/ Tenerife, Anaga Mts.
GB 2111/ Deciduous wood/ Tenerife, Anaga Mts.
GB 2122/ Deciduous wood/ Tenerife, Anaga Mts.
GB 2192/ Deciduous wood/ Turkey, in mixed *Picea* forest.
GB 26/ Deciduous wood/ Sweden, Bohuslän.
GB 1807/ Deciduous wood/ Spain, Lerida.

The tested specimens were found to be compatible. Almost all were growing on rather thin twigs. No morphological differences noted between the fruitbodies.

Peniophora nuda (Fr.) Bres.
Description: Eriksson et al. (1978).
Material tested:
GB 2193/ Deciduous wood/ Turkey, in *Picea* forest with scattered *Fagus*.
GB 3/ *Ulmus carpinifolia*/ Sweden, Gotland.
GB 5/ *Ulmus carpinifolia*/ Sweden, Öland.
GB 1967/ *Fagus*/ Sweden, Halland.
GB 1808/ Deciduous wood/ France, Pyrenees Orientales (*Peniophora violaceolivida* (Sommerf.) Mass.).
GB 86/ Deciduous wood/ Iran, Gorgan (*P. pseudonuda* Hallenb.).

GB 2193 was incompatible with the known sibling species in *P. nuda* (see Hallenberg, 1986 b), as well as with the closely related *P. violaceolivida* and *P. pseudonuda*. In fruitbody morphology the Turkish collection comes very close to *P. nuda* but there are some minute differences. In GB 2193 there are abundant rounded sulfocystidia in, or originating from, the brown subicular layer, and besides, there are hymenial sulfocystidia, cylindrical to sinuose, up to 7 µm wide. In *P. nuda*, sulfocystidia are, as a rule not abundant and they are scattered throughout the fruitbody and not located into two different levels.

Peniophora meridionalis Boid.
Description: Boidin (1958).
Material tested:
GB 2116/ Deciduous wood/ Gomera, Garajonay Nat. Park.
GB 2124/ Deciduous wood/ Tenerife, Anaga Mts.

Compatibility was shown between the two specimens. In fruitbody morphology they agree well with each other and with herbarium material from Europe (Italy).

Peniophora rufomarginata (Pers.) Litsch.
Description: Eriksson et al. (1978).
Material tested:
GB 2110/ Deciduous wood/ Tenerife, Anaga Mts.
GB 1181/ *Tilia*/ Norway, Rogaland.
GB 1471/ Deciduous wood/ Romania, Iasi.
GB 1473/ *Tilia*/ Romania, Iasi.

Partial compatibility was found between GB 2110 and the other specimens of *P. rufomarginata*:

	GB 1181-3	GB 1181-5	GB 1471-1	GB 1471-2	GB 1473-1	GB 1473-2
GB 2110-1	-	-	-	+	+	+
GB 2110-2	+	-	-	-	+	+
GB 2110-3	-	-	-	+	+	+
GB 2110-4	(+)	-	-	-	+	+

Polarity tests for GB 2110 showed that SS-1 and SS-3 belong to the same mating type and they were compatible with SS-2,4. Matings between GB 2110 and GB 1473 resulted in abundance of vigorously growing, aerial mycelium and clamps were present in all parts of the petri dish. In other combinations where clamps were found, these were few and restricted to the confrontation area. No aerial mycelium was formed in these cases.

The specimen from Tenerife differs from (European) *P. rufomarginata* by having fruitbodies with a black margin which is adnate and not loosening from the substrate. European specimens (including the type specimen) have light coloured margins and the fruitbodies are typically loosening from the substrate. This is a striking difference which could make the difference between it and *P. limitata* uncertain. However, in the latter species the spores are distinctly longer.

Peniophora versicolor (Bres.) Sacc. & Syd.
Description: Eriksson (1950).
Material tested:
GB 2108/ *Persea*/ Tenerife, Anaga Mts.
GB 2115/ *Erica*/ Gomera, Garajonay Nat. Park.

The two specimens were compatible. The fruitbodies were compared with the type and found to agree well in morphology.

Phlebia livida (Fr.) Bres.
Description: Eriksson et al. (1981).
Material tested:
GB 2127/ Unidentified wood/ Tenerife, Anaga Mts.
GB 2128/ *Laurus*/ Tenerife, Anaga Mts.
GB 2221/ *Fagus*/ Turkey, in timber stores near the coast.
GB 2222/ *Alnus*/ Turkey, in *Alnus* forest by a river.
GB 2242/ *Alnus*/ Turkey, in mixed *Alnus* forest on a slope.
GB 1455/ *Fagus*/ Sweden, Västergötland.
GB 1812/ *Fagus*/ Spain, Huesca.
GB 1814/ *Abies*/ Spain, Lerida.
GB 1290/ *Picea*/ Sweden, Halland (*P. livida*, "*Picea* type").

The specimens were found to be compatible with each other, except for matings with GB 1290. Hallenberg (1988) reported that two sibling species exist in this complex. The main group studied here has been named "broad-leaved and *Abies* type"-and includes 5 more specimens from Europe. The other group, "*Picea* type", is here represented by GB 1290.

In fruitbody morphology there is a certain variation which mainly concerns the external features ("broad-leaved and *Abies* type"). The colour may be greyish, ochraceous, brownish, or reddish violaceous and the hymenophore may vary from almost smooth with few, small, and scattered tubercles to densely tuberculate. In such specimens the tubercles are frequently aggregated and irregularly distributed over the hymenial surface. The substrate is always white-rotted but fruitbodies may be found on both bark and lignum as well as on burnt wood. There does not seem to be any correlation between external morphology and geographical origin with except for the Turkish collections, which all were greyish and almost smooth. No noticeable difference was observed between the tested specimens in their micromorphology.

Phlebia rufa (Fr.) M.P. Christ.
Description: Eriksson et al. (1981).
Material tested:
GB 2209/ Deciduous wood/ Turkey, in mixed *Alnus* forest on a slope.
GB 1790/ *Fagus*/ Spain, Huesca.
GB 1936/ *Quercus*/ Denmark, Jylland.
GB 1792/ *Fagus*/ Spain, Huesca (*P. radiata* Fr.)
GB 1940/ *Quercus*/ Denmark, Jylland (*P. radiata*).

The specimen from Turkey (GB 2209) was incompatible with both representatives of *P. rufa* and *P. radiata*. These two species are closely related, morphologically separated by different hymenophore features and a slight difference in size and shape of the spores. There are also ecological differences between the two species (Boddy & Rayner, 1983).

The Turkish specimen is here referred to as *P. rufa* s.l. because the hymenophore is wrinkled in the same way as in this species, while the spores are intermediate between *P. rufa* and *P. radiata* (4.5-5 x 2-2.3 µm). However, the most prominent difference is the structure of a gelatinous basal layer, about 100 µm thick, next to the subiculum. Also in *P. rufa* and *P. radiata* there is a basal layer where individual hyphae are united by gelatinous substances but the individual hyphae are here discernable and hyphal walls are just thickened. In GB 2209 the basal layer is distinct, individual hyphae (reaching 8 µm width) are running parallel and are hardly discernable. Frequently, hyphal walls are strongly gelatinized, and the cells have only a narrow lumen (sections mounted in 2 % KOH). Without any doubts this specimen represents a separate taxon but further documentation is desirable before describing it as a new species.

Phlebia segregata (Bourd. & Galz.) Parm.
Description: Eriksson et al. (1981).
Material tested:
GB 2274/ *Picea*/ Turkey, in mixed *Picea* forest.
GB 1329/ *Picea*/ Sweden, Gotland.
GB 1841/ *Pinus*/ Spain, Huesca.

Complete compatibility between the tested specimens. No morphological differences were observed between the fruitbodies. Also a specimen from Finland belongs to this group of compatible specimens (Hallenberg, 1987 b). All these collections are from decorticated, brown-rotted wood of conifers.

Phlebiella ardosiaca (Bourd. & Galz.) Larss. & Hjortst.
Description: Hjortstam et al. (1988), Hjortstam & Ryvarden (1979, as *Xenasmatella decipiens* Hjortst. & Ryv.).
Material tested:
GB 2244/ *Alnus*/ Turkey, in mixed *Alnus* forest on a slope.
GB 1532/ *Fraxinus*/ Romania, Iasi.
GB 1539/ Deciduous wood/ Romania, Brasov.
GB 2285/ *Quercus*/ France, Landes/ Coll. Gilles.
GB 2042/ *Fagus*/ Denmark, Jylland (*P. tulasnelloidea* (Höhn. & Litsch.) Oberw.).

Complete compatibility was found between the tested cultures of *P. ardosiaca*, but incompatibility with the very closely related *P. tulasnelloidea*. An exception was the matings between GB 2244-SS-2 x GB 2042-SS-1,2 where true and false clamps were formed along the confrontation zone. However, as cultured mycelia in these species have very narrow hyphae and clamps which may be very irregular, nuclear staining was performed. Mycelia were then subcultured in liquid medium under a collodium film on a microscope slide and nuclei were stained with Giemsa (Boidin, 1958). The observed hyphal cells were to a high degree dikaryotic and both true and false clamps were present also here. Even if such a hybrid would not survive in nature, the results underline a close relationship between the two species. A hybrid between two closely related species in Aphyllophorales has earlier been obtained in the laboratory. Boidin & Lanquetin (1983 b) showed that matings between haploid mycelia of *Dichostereum durum* (Bourd. & Galz.) Pilat and *D. sordulentum* (Cke. & Mass.) Boid. & Lanq. could result in formation of secondary mycelium and fruitbodies. The progeny was, however, homothallic.

In fruitbody morphology no differences were observed among the tested specimens of *P. ardosiaca*. The difference towards *P. tulasnelloidea* is small and restricted to the size and shape of the spores. Also in diagnostic culture tests, only minute differences were found between the two species (Hallenberg, 1986 a, *P. ardosiaca* was here designated as a sibling species in *P. tulasnelloidea* - "Central European type"). All tested specimens of *P. ardosiaca* were growing on decorticated wood where the surface was dark coloured due to previous attack by ascomycete fungi. In *P. tulasnelloidea* the substrate is frequently covered with green algae.

Radulomyces confluens (Fr.) M.P. Christ.
Description: Eriksson et al. (1981).
Material tested:
GB 2146/ Deciduous wood/ Tenerife, Aqua Mts.
GB 1071/ Deciduous wood/ Romania, Bistrita.
GB 1705/ Deciduous wood/ Finland, North Häme.
GB 1818/ *Fagus*/ Spain, Navarra.

Clamps were produced in all combinations in this test. However, a striking barrier was formed on the confrontation line in all combinations between GB 2146 and the other cultures. In the tests, GB 2146 was represented by all four mating types and in combinations with one of these (GB 2146-SS-2), clamp formation was restricted to a narrow zone along the confrontation line.

No differences in fruitbody morphology were observed. However, the formation of barriers and the indication of restricted nuclear migration in the pairing tests shows that GB 2146 is geneticaly isolated from the European cultures.

Repetobasidium mirificum John Erikss.
Description: Eriksson et al. (1981).
Material tested:
GB 2268/ *Picea*/ Turkey, in *Picea* forest.
GB 2020/ *Pseudotsuga*/ Canada, B.C., Vancouver Isl.

Compatibility exists between the two specimens. In fruitbody morphology they were very similar, differing only minutely in spore shape. The spores in the Canadian collection were subglobose - broadly ellipsoid while they were strictly subglobose in the GB 2268.

Resinicium bicolor (Fr.) Parm.
Description: Eriksson et al. (1981).
Material tested:
GB 2228/*Picea*/ Turkey, in *Picea* forest with scattered *Fagus*.
GB 1821/ *Abies*/ Spain, Lerida.
GB 1932/ *Picea*/ Denmark, Jylland.
GB 2187/ *Picea*/ Estonia, Lahemaa Nat. Park.

The tested specimens were found to be compatible, but in the combination GB 1932-SS-1 x GB 2187-SS-1 a distinct barrier was formed between the two mycelia and only few clamps were seen along this zone. Altogether, 15 intercompatible specimens have now been found to be compatible from Europe and Canada (Hallenberg, 1984 a, 1988). These specimens were collected on white-rotted, coniferous wood, once on *Populus*.

No morphological differences have been observed between fruitbodies from the tested specimens, with exception for the spore length (GB 2228: 5-6 µm long, GB 1821: 6-7µm, GB 1932: 5.5-6m, GB 2187: 5.5-7µm). A specimen from Canada was earlier found to be compatible with European ones despite the former having unusually short spores (4.5-5.5 µm long, see Hallenberg, 1984 a).

Schizopora flavipora (Cke.) Ryv.
Descriptions: Gilbertson & Ryvarden (1987), Eriksson et al. (1984; illustration only and under the name *S. carneolutea* (Rod. & Cle.) Kotl. & Pouz.).
Material tested:
GB 2233/ *Alnus*/ Turkey, in *Alnus* forest by a river.
GB 1053/ *Fagus*/ Romania, Iasi.

The two specimens were compatible. The only difference, observed in fruitbody morphology, was the presence of pseudopilei in the Romanian collection, due to vertical growth. Three additional specimens from France belong to this compatibility group. A specimen from Brazil (Sao Paulo, coll. Hjortstam) has been found to be partially compatible with representatives for the group considered here.

Schizopora radula (Fr.) Hallenb.
Description: Niemelä (1987), Eriksson et al. (1984).
Material tested.
GB 2134/ Deciduous wood/ Tenerife, Aqua Mts.
GB 2135/ Deciduous wood/ Tenerife, Anaga Mts.
GB 2136/ Deciduous wood/ Tenerife, Anaga Mts.
GB 2239/ *Carpinus*/ Turkey, in mixed *Picea* forest.
GB 1055/ *Fagus*/ Romania, Iasi.
GB 1958/ Deciduous wood/ Denmark, Jylland.
GB 1972/ *Quercus*/ Denmark, Jylland.
GB 2019/ *Alnus*/ Canada, B.C., Vancouver Isl.

The tested specimens were compatible. Additional cultures belonging to this species are reported by Hallenberg (1983).The tested specimens were found to agree well with each other in micromorphology. It is, however, noteworthy that the projecting hyphae in pore mouths of GB 1972, were naked, while they normally are covered with abundant crystalline material. The variable external morphology in this species has been discussed earlier (Hallenberg, 1983). For separating characters between *S. radula* and the closely related S. *paradoxa*, see Niemelä (1987).

Hitherto, most authors have failed to treat the two species separatly and both have frequently been reported under the name *S. paradoxa*. Judging from pairing tests made up till now, *S. radula* seems to be the most widespread one, while cultures of *S. paradoxa* only have been obtained from the Nordic countries and from Romania.

Sistotrema brinkmannii (Bres.) John Erikss.
Description: Eriksson et al. (1984).
Material tested:
GB 2206/ *Alnus*/ Turkey, in *Alnus* forest by a river.
GB 2213/ *Alnus*/ Turkey, in *Alnus* forest by a river.
GB 235/ Deciduous wood/ Denmark, Jylland.
GB 315/ Deciduous wood/ Sweden, Närke.
GB 1010/ Deciduous wood/ Romania, Bihor.
GB 1025/ *Pinus*/ Romania, Suceava.
GB 2198/ *Alnus*/ Turkey, in *Alnus* forest by a river.
GB 2215/ *Alnus*/ Turkey, in *Alnus* forest by a river.
GB 2217/ *Fagus*/ Turkey, in *Picea* forest with scattered *Fagus*.

Compatibility was found between specimens in the first group (GB 2206, GB 2213, GB 235, GB 1010, GB 1025). Compatibility was also found between GB

2198 and 2215, but these cultures were incompatible with the first group as well as with all available sibling species within this complex (*S. brinkmannii* - *S. oblongisporum*). Nevertheless, GB 2198 and GB 2215 were collected in the same area of uniform vegetation as GB 2206 and GB 2213 and no morphological or ecological characters could be found to distinguish these four specimens from each other.

Incompatible sibling species, apparently occupying the same kind of niche within the same local area, have earlier been reported by Ullrich (1973) in his study on the *Sistotrema brinkmannii* complex. What Ullrich had in his hand is impossible to know today, as no herbarium material or cultures have been preserved from his investigation. Moreover, the species concept used by him was likely similar to that of Lemke (1969) which definitively was a very broad one, comprising several species which later have been found to be easily recognizable (Hallenberg 1984 b). Nevertheless, with a much more narrow concept applied, the same conclusion has been reached here: morphologically identical but intersterile specimens may occur in nature very close to each other.

The main compatibility group of *S. brinkmannii* (the first group in this study) now includes 20 specimens from Europe and N. America, which have been collected on a variety of substrates, mainly deciduous wood.

The last specimen mentioned in the list, GB 2217, was also found to be incompatible with above mentioned cultures, as well as with other available sibling species within this complex. This specimen is easily distinguished morphologically but is listed as *S. brinkmannii* s.l. because of great similarities in spores and basidia. The fruitbody is thin, ceraceous, and subinvisible when dried. The spores are not allantoid but with the adaxial side straight and the subhymenium consist of densely united hyphae, irregularly branched and forming a compact tissue, which is in contrast to a much more open tissue in typical *S. brinkmannii*. Without any doubt GB 2217 represents a taxon of its own but the description of a new species should wait until more material has become available.

Sistotrema oblongisporum M.P. Christ. & Hauersl.
Description: Eriksson et al. (1984).
Material tested:
GB 2219/ *Alnus*/ Turkey, in mixed *Alnus* forest on a slope.
GB 303/ *Alnus*/ Sweden, Västmanland.
GB 512/ Deciduous wood/ Sweden, Värmland.
GB 2117/ *Pinus*/ Tenerife, Esperanza Mts.
GB 2118/ *Pinus*/ Tenerife, Esperanza Mts.
GB 2149/ *Eucalyptus*/ Tenerife, Anaga Mts.
GB 1490/ Deciduous wood/ Romania, Covasna.
GB 1954/ *Quercus*/ Denmark, Jylland.

The first group of specimens (GB 2219, GB 303, GB 512) were found to be compatible and no differences could be observed in their fruitbody morphology. These specimens belong to the main compatibility group distinguished, which now consists of 7 specimens from N. Europe, Turkey, Canada (B.C.) and Australia (Hallenberg, 1984 b).

The second group consists of specimens which have been found to be incompatible with any other group within *S. brinkmannii* - *S. oblongisporum* complex as well as with each other. Because of morphological similarities they have been listed as *S. oblongisporum* s.l. Concerning the Tenerife-specimens it has been indicated that both GB 2117 and GB 2149 are bipolar (which is normal for this group of *Sistotrema*-species), while GB 2118 seems to be homothallic and is morphologically very close to GB 2117. On the whole, the morphological differences within this group of incompatible specimens are extremely small. GB 2117 and GB 2118 have both a thin but submembranaceous fruitbody, with a smooth, continuous hymenium. In *S. oblongisporum* s.str. the fruitbodies are thin and porulose. GB 2149 is morphologically almost indistinguishable from the main group of compatible specimens in *S. oblongisporum*.

Sistotremastrum niveocremeum (Höhn. & Litsch.) John Erikss.
Description: Eriksson et al. (1984).
Material:
GB 2112/ *Eucalyptus*/ Tenerife, Anaga Mts.
GB 2125/ Deciduous wood/ Tenerife, Anaga Mts.
GB 2153/ Deciduous wood/ Gomera, Garajonay Nat. Park.
GB 2231/ *Alnus*/ Turkey, in *Alnus* forest by a river.
GB 2265/ *Picea*/Turkey, in *Picea* forest.

These specimens were all indicated to be homothallic, as all isolated single-spore cultures were clamped. Boidin (1958) found that *S. niveocremeum* could be either heterothallic or homothallic and in both cases the nuclear behaviour was normal and the spores were uninucleate. Among the nine European cultures of this species which are available in the GB culture-collection, eight are indicated to be homothallic. In one specimen (GB 2153), isolated single-spore cultures were clampless, polarity tests were carried out, and heterohallism shown. A year later, however, all these cultures had become clamped.

In the description of the species in Eriksson et al. (1984) a large variation in the sizes of microscopical details was reported (spores: 6-9 x 2.5-4 µm; basidia: 15-26 x 4-7 µm). This big variation has also been found among homothallic specimens studied here. Moreover, from the description for the species it appears that both 4- and 6-sterigmate basidia occur. However, in the material studied here there is a distinct difference between individual specimens in the proportion of 4- to 6-sterigmate basidia, and this correlats with spore sizes:

	Spore size (µm)	*Percentage of 6-sterigmate basidia*
GB 2112	6.5-7 x 3-3.5	80
GB 2125	6.5-8 x 3-3.8	10
GB 2153	7-8 x 3.5-4	5
GB 2231	5.5-6 x 2.8-3	75
GB 2265	7-8 x 3.5-4	5

The percentage of 6-sterigmate basidia are based upon 20 randomly selected basidia per specimen. The spore sizes were measured from spore prints. Obviously, specimens with mainly 4-sterigmate basidia have slightly bigger spores and conversely. It seems probable that a relatively simple genetical factor may regulate the proportions between 4- and 6-sterigmate basidia and, furthermore, it seems probable that the spore size is affected by this number. Consequently, it is reasonable to accept the very big variation in spore size as an intraspecific character.

All specimens studied here were found on lignum and the wood was rather strongly white-rotted, except in GB 2112 where the substrate (*Eucalyptus*) was hard and apparently undecayed.

Steccherinum bourdotii Saliba & David
Description: Saliba & David (1988).
Material tested:
GB 2236/ *Alnus*/ Turkey, in *Alnus* forest by a river.
GB 1029/ Deciduous wood/ Romania, Bistrita-Nasaud.

Compatibility was found between the two specimens and no morphological differences were observed.

Saliba & David (1988) used intercompatibility tests to study the distribution of this species as well as delimitations towards *S. ochraceum* (Fr.) S.F. Gray. *S. bourdotii* is separated from *S. ochraceum* by having subglobose spores instead of ellipsoid. The distribution in Europe is mainly southern and the species is obviously widely distributed. One of the specimens used by Saliba & David in their intercompatibility tests was collected in Argentina, another one was GB 1029, used here as a tester for the species.

Steccherinum ochraceum (Fr.) S.F. Gray
Description: Eriksson et al. (1984).
Material tested:
GB 2237/ *Corylus*/ Turkey, in mixed *Picea* forest.
GB 352/ *Corylus*/ Sweden, Uppland.

Compatibility was found between the two specimens by using di-mon tests (only a polyspore mycelium was available from GB 352). No morphological differences were observed between their fruitbodies. None of the specimens has been crossed with representatives of the different sibling species in *S. ochraceum* complex (Saliba & David, 1988), but as *S. ochraceum* s.str. seems to be the one with the most northern distribution, this may also be the correct name for the specimens dealt with here.

Trichaptum abietinum (Fr.) Ryv.
Description: Ryvarden (1978).
Material tested:
GB 2123/ *Pinus*/ Tenerife, Esperanza Mts.

GB 132/ *Picea*/ Sweden, Dalarna.
GB 982/ Coniferous wood/ Sweden, Västergötland/ Coll. Daun.
GB 1023/ *Picea*/ Romania, Bistrita-Nasaud.
GB 1102-04/ *Pinus*/ Norway, N. Tröndelag/ Coll. Daun.
GB 1109/ *Picea*/ Sweden, Dalarna/ Coll. Daun.
GB 1115/ *Picea*/ Sweden, Västergötland/ Coll. Daun.
GB 1129/ *Picea*/ Sweden, Skåne/ Coll. Daun.
GB 1185/ *Pinus*/ Norway, Sogn & Fjordane.
GB 1186/ *Picea*/ Norway, Hordaland.
GB 1219/ *Picea*/ Sweden, Jämtland/ Coll. Daun.
GB 1370/ *Picea*/ Sweden, Jämtland/ Coll. Daun.
GB 1696/ *Picea*/ Finland, South Häme.
GB 1789/ *Abies*/ Spain, Huesca.

Compatibility was found between these specimens. In fruitbody morphology all specimens were very similar to each other with exception for the somewhat larger pores in the specimen from Tenerife. Intercompatibility for this species has earlier been thoroughly investigated (Macrae, 1966, Magasi, 1976) but these studies were mainly based on N. American collections with just a few representatives from Europe.

Tubulicrinis gracillimus (Rog. & Jacks.) Cunn.
Description: Hjortstam et al. (1988).
Material tested:
Group 1. GB 2148/ Deciduous wood/ Tenerife, Anaga Mts.
GB 2166/ Deciduous wood/ Tenerife, Anaga Mts.
Group 2. GB 2157/ *Pinus*/ Tenerife, Esperanza Mts.
GB 1869/ *Pinus*/ Spain, Lerida.
GB 2038/ *Chamaecyparis*/ Canada, B.C., Vancouver Isl.
Group 3. GB 912/ *Betula*/ Sweden, Lycksele Lappmark.
GB 1965/ *Alnus*/ Greenland.
Group 4. GB 1251/ *Picea*/ Norway, Oppland.
GB 1253/ *Picea*/ Norway, Oppland.

Four groups have been found within this complex. Compatibility was found within each group, incompatibility between them. The only deviation observed hitherto is the partial compatibility between GB 2038 (Canada) and GB 1869 (Spain) and GB 2157 (Tenerife). In each of these intercontinental matings 6 pairings were positive and 2 negative.

The complex situation in this species has been reported earlier (Hallenberg, 1986), and additional specimens to group 3 are listed there. Distribution for the different compatibility groups are given in Fig. 4.

In fruitbody morphology there are only minute differences and all groups fit the delimitations given in Hjortstam et al. (1988) for *T. gracillimus*. In all tested specimens there is a moderate amyloid reaction in the lyocystidia. In group 1 specimens the frequency of lyocystidia seems to be somewhat higher than in the other groups but the shape of lyocystidia is very similar between the different groups. Spore sizes varies minutely; in group 1, 7-8.5 x 2 µm; in group 2, 7.5-9 x 2 µm; in group 3, 6-8 x 1.8-2 µm; in group 4, 7-8 x 1.8-2 µm.

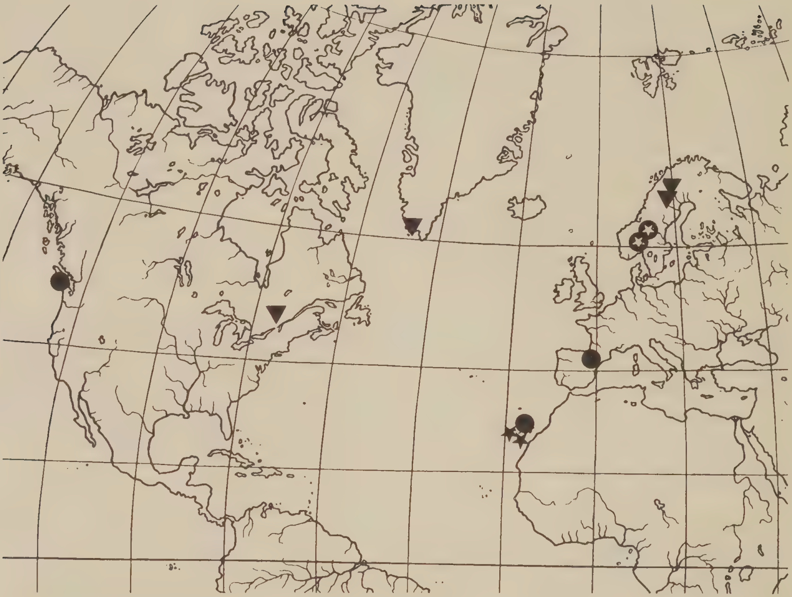


Fig. 4. Distribution of the different compatibility groups in *Tubulicrinis gracillimus*. ★ = group 1, ● = group 2, ▼ = group 3, ✪ = group 4.

On the contrary, the differences in substrate preferences are striking. Group 1 and 3 specimens were found on white-rotted deciduous wood, group 2 on rather hard, brown-rotted wood of *Pinus* and *Chamaecyparis*, group 4 on *Picea* wood, decayed by *Trichaptum* (white pocket rot).

Tubulicrinis strangulatus Larss. & Hjortst.
Description: Hjortstam et al. (1988).
Material tested:
GB 2273/ *Picea*/ Turkey, in *Fagus* -, *Abies* -, *Picea* forest.
GB 1744/ *Picea*/ Sweden, Västergötland.
GB 1866/ *Abies*/ Spain, Huesca.
GB 795/ *Pseudotsuga*/ Canada, B.C. Vancouver Isl. (*T. borealis* John Erikss.)
GB 1754/ *Picea*/ Sweden, Västergötland (*T. borealis*).

Compatibility was found between tested specimens of *T. strangulatus* while they were incompatible with *T. borealis*. The two species are closely related both in fruitbody morphology and in ecology. Distinctive separating characters are treated in Hjortstam et al. (1988), culture studies and additional compatibility tests are reported by Hallenberg (1986 a). Altogether, the compatibility group in *T. strangulatus* now consists of 7 specimens (Sweden, Norway, Spain, Romania, Turkey). There is a small morphological variation among the specimens in *T. strangulatus* which mainly concerns the amyloidity of lyocystidia and basidia as well as the thickness of the basidial walls.

An interesting observation was made in connection with a special study of *T. borealis*. Four collections were made on two closely associated logs of *Picea*. In one of these both *T. borealis* and *T. strangulatus* occurred side by side, their fruitbodies being separated just 4 mm from each other. The determinations were confirmed by compatibility tests. A direct comparison showed that the amyloidity of basidial walls were distinctly stronger and their walls thicker in *T. borealis* compared with *T. strangulatus*.

Vuilleminia comedens (Fr.) Maire
Description: Hjortstam et al. (1988).
Material tested:
GB 2227/ *Alnus*/ Turkey, in *Alnus* forest by a river.
GB 2230/ *Alnus*/ Turkey, in mixed *Alnus* forest on a slope.
GB 1697/ *Alnus*/ Finland, North Häme.
GB 1806/ Deciduous wood/ Spain, Lerida.

Compatibility was found between the tested specimens and no morphological differences were observed. Altogether, there are now 6 specimens in this compatibility group (Finland, Scotland, Spain, Sweden, Turkey).

Vuilleminia cystidiata Parm.
Description: Hjortstam et al. (1988).
Material tested:
GB 2154/ Deciduous wood/ Tenerife, Anaga Mts.
GB 2145/ *Rosa*/ Sweden, Bohuslän.

Compatibility was found between the two specimens (16 matings). The species is apparently widespread. Parmasto (1965) reports it from different parts of the Soviet Union, Hallenberg (1978) from N. Iran, and there are records from different parts of Europe (Boidin & Lanquetin, 1983 a, Hjortstam et al., 1988). The substrate varies but is always branches of deciduous trees. Species of *Prunus* and *Rosa* seem to be prefered everywhere. However, the spore measurements given by different authors vary. The two specimens tested here also have different spore sizes even though other morphological characters coincide well. The different values reported are summarized:

Source	*Spore size (μm)*
Parmasto (1965)	12-16 x 3.7-5.5
Boidin et al. (1989)	13.5-17 x 3.5-5
Hjortstam et al. (1988)	15-20 x 4.5-6
GB 2145 (spore-print)	18-19 x 4-4.5
GB 2154 (spore-print)	16.5-18 x 5.5-7

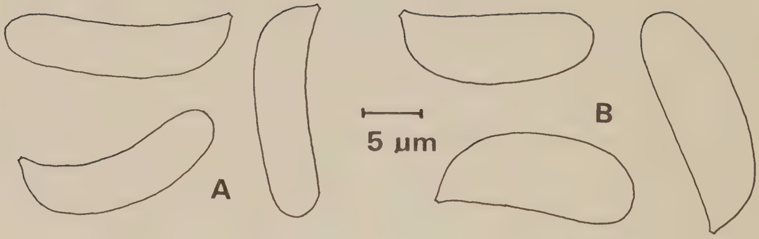


Fig. 5. *Vuilleminia cystidiata*. A, spores in GB 2145. B, spores in GB 2154.

It is interesting to note that the spores in GB 2154 differ considerably in shape and size from the compatible specimen, GB 2145 (Fig. 5). The difference in spore shape is so striking that they very well could be treated as separate taxa on morphological criteria only.

DISCUSSION

As mentioned in the introduction the number of endemic species of higher plants is great in Canary Islands and in N. E. Turkey, while the results presented here for the wood-fungus flora show a high similarity with Europe and Canada. On the other hand, the number of sibling species has increased. A noticeable genetical differentiation has also been indicated in some species when compared with European material. In both *Vuilleminia cystidiata* and *Peniophora rufomarginata* there are distinct morphological differences between Canarian and European collections, although they are compatible, at least partially. In *Radulomyces confluens* a distinct barrier was formed between European collections and the one from Tenerife while still being compatible. Partial compatibility was found in several species even if no morphological or ecological differences were revealed in this study. Still, particular efforts were made to detect minute differences between the tested specimens. In those cases where partial compatibility was found, this was obviously of heterogenic nature (Esser & Blake, 1973) and not depending on identical mating type factors. This kind of intersterility has been supposed to be of great importance in speciation processes (Chase & Ullrich, 1990; Hallenberg 1988).

The species studied here are relatively common in suitable habitats, and well distributed over the N. hemisphere. They do not constitute a selected set of species but are merely the result of intense collecting during short field periods. Thanks to the accumulated information from pairing tests during the last decades it is now possible to form an opinion about the degree of genetic isolation in this wood-fungus flora. Among interpairing tests performed during the last ten years at Gothenburg University, only few cases with partial compatibility have been found between European (non-Mediteranean) specimens. Among interpairing tests between specimens from Europe versus Canary Islands and N. E. Turkey, partial compatibility or other genetically regulated differences have been found in 20 - 25 % of the investigated species. This is the same figure as found from interpairing tests between European and Canadian specimens.

The occurrence of strictly incompatible sibling species within a complex is more difficult to evaluate in connection with genetical isolation. In earlier studies it has been found that some sibling species really are phylogenetically closely related, like in *Peniophora cinerea* (Hallenberg, 1986 b). Others are only superficially similar in their fruitbody morphology without any closer phylogenetic relationship, like in *Phlebia lilascens* (Bourd.) Erikss. & Hjortst. (Hallenberg & Larsson, 1991). Sometimes, single and isolated, incompatible specimens within a complex will later be found to be geographically widespread when more cultures have become available for testing. Examples of this kind has been demonstrated in this paper for *Hyphodontia subalutacea* and *Tubulicrinis gracillimus*. The occurrence of partial compatibility and morphological or ecological differentiation, seem to be more reliable factors when estimating the genetical isolation between geographically well separated populations.

It is easy to understand that the wood-fungus flora in phytogeographically isolated areas also will show up some genetical differentiation towards the main population of these species. On the contrary, the high similarity in this flora between Europe and Canary Islands and N. E. Turkey needs further comment. A reasonable explanation, which also was touched upon in Hallenberg (1987 b) could be:

1. The driving force in nature for creating endemism and other kinds of genetical differentiation among higher plants is of different nature in wood-fungi. Wood-inhabiting basidiomycetes have a most intimate relation to their particular substrates. As long as the substrate (mainly dead wood) or other environmental parameters (other competing wood-fungi; microclimate in the forest) have undergone only small changes during a long time of biohistory, this driving force will be less important.

2. It is probable that the main distribution of wood-fungi during their biohistory has been closely connected and contemporary with the distribution of forests (Hallenberg, 1987 b). During the Tertiary, Canarian forest trees of today were also widespread in Europe, where they occurred in contact with other temperate forests. It is very tempting to accept that the wood-fungus flora was the same at that time and just as common between different kind of forest trees as they are today. Later phytogeographical changes must not have affected the wood-fungus flora.

ACKNOWLEDGEMENTS

I want to thank C. Ata, Trabzon, and his staff at the Black Sea Technical University, and E. Beltran Tejera, La Laguna, for kind and valuable help during the field work. Several persons, mentioned in the text, have supplied spore prints or specimens for cultivation. The extensive laboratory work was performed by E. Larsson, Göteborg. J. Ginns, Ottawa, and T. Niemelä, Helsinki, have kindly reviewed the manuscript. Financial support was given by Swedish Natural Science Research Council and the foundation of Anna and Gunnar Vidfelt.

REFERENCES

Aguilar, J.del A. 1989. El origen de la flora canaria. Quercus 41: 14-21.

Beltran Tejera, E. 1980. Catalogo de los hongos saprofitos presentes en el archipelago Canario. Instituto de estudios Canarios en la universidad de La Laguna, Monografias seccion IV, XVII, pp. 1-47.

Boddy, L., Rayner, A.D.M. 1983. Mycelial interactions, morphogenesis and ecology of *Phlebia radiata* and *Phlebia rufa* from oak. Trans. Br. Mycol. Soc. 80: 437-448.

Boidin, J. 1958. Essai biotaxonomique sur les Hydnés résupinés et les Corticiés. Rev. Mycol. (Paris) Mém. 6: 1-387.

Boidin, J., Lanquetin, P. 1983 a. Les genres *Vuilleminia* et *Corticium* (Basidiomycetes) en France. Bull. Soc. Mycol. Fr. 99 (3): 269-279.

-, and -. 1983 b. Obtention de mycéliums et de fructifications hybrides entre *Dichostereum durum* et *D. sordulentum* (Basidiomycetes). Cryptogamie Mycol. 4: 375-402.

, and . 1984. Indices of useful information for incompatibility tests in Basidiomycetes. III. Non poroid Aphyllophorales. Cryptogamie Mycol. 5: 193-245.

Bramwell, D. 1972. Endemism in the flora of the Canary Islands. In D. H. Valentine (ed.) Taxonomy, Phytogeography and Evolution. Pp. 241-254. Academic Press, London & New York.

Burdsall Jr, H. H., Lombard, F. F. 1976. The genus *Gloeodontia* in North America. Mem. New York Bot. Gard. 28 (1): 16-31.

Chase, T. E., Ullrich, R. C. 1990. Five genes determining intersterility in *Heterobasidion annosum*. Mycologia 82: 73-81.

David, A. 1972. Comportement nucléaire des représentants du genre *Gloeoporus* Mont.: *G. conchoides* Mont., *G. dichrous* (Fr.) Bres. et *G. pannocinctus* (Rom.) J. Erikss. récolté pour la première fois en France. Bull. Soc. Mycol. Fr. 88 (2): 209-213.

Domanski, S. 1979. *Polyporus dichrous* Fr. and *Polyporus pannocinctus* Romell in culture. Acta Soc. Poloniae. 39 (3): 531-38.

Eriksson, J. 1950. *Peniophora* Cke. sect. *Coloratae* Bourd. & Galz. A taxonomical study with special reference to the Swedish species. Symb. Bot. Ups. 10: 1-76.

Eriksson, J., Ryvarden, L. 1973. The Corticiaceae of North Europe. Vol. 2. Pp. 59-286. Fungiflora, Oslo.

-, -. 1975. Ibid. Vol. 3. Pp. 287-546. Fungiflora, Oslo.

-, -. 1976. Ibid. Vol. 4. Pp. 547-886. Fungiflora, Oslo.

Eriksson, J., Hjortstam, K., and L. Ryvarden. 1978. The Corticiaceae of North Europe. Vol. 5. Pp. 887-1047. Fungiflora, Oslo.

, , and . 1981. Ibid. Vol. 6. Pp. 1048-1276. Fungiflora, Oslo.

-, -, and -. 1984. Ibid. Vol. 7. Pp. 1277-1449. Fungiflora, Oslo.

Esser, K., Blaich, R. 1973. Heterogenic incompatibility in plants and animals. Adv. Genet. 17: 107-52.

Gilbertson, R. L., Ryvarden, L. 1986. North American polypores. Vol. 1. *Abortiporus - Lindtneria*. Pp. 1-433. Fungiflora, Oslo.

Hallenberg, N. 1978. Wood-fungi (Cortriciaceae, Coniophoraceae, Lachnocladiaceae, Thelephoraceae) in N. Iran. I. Iran. Journ. Plant. Path. 14: 38-87.

-. 1980. New taxa of Corticiaceae from N. Iran (Basidiomycetes). Mycotaxon 11: 447-475.

-. 1983. On the *Schizopora paradoxa* complex (Basidiomycetes). Mycotaxon 18: 303-13.

-. 1984 a. Compatibility between species of Corticiaceae s.l. (Basidiomycetes) from Europe and North America. Mycotaxon 21: 335-388.

-. 1984 b. A taxonomic analysis of the *Sistotrema brinkmannii* complex (Corticiaceae, Basidiomycetes). Mycotaxon 21: 389-411.

-. 1985 a. On the *Hypochnicium eichleri* complex (Basidiomycetes). Mycotaxon 24: 431-36.

-. 1985 b. Compatibility between species of Corticiaceae s.l. (Basidiomycetes) from Europe and Canada. II. Mycotaxon 24: 437-43.

-. 1986 a. Cultural studies in *Tubulicrinis* and *Xenasmatella* (Corticiaceae, Basidiomycetes). Mycotaxon 27: 361-375.

-. 1986 b. On speciation and species delimitation in *Peniophora cinerea*-group (Corticiaceae, Basidiomycetes). Windahlia 16: 73-80.

-. 1987 a. On speciation in Corticiaceae. Windahlia 17: 19-25.

-. 1987 b. Culture studies in Corticiaceae (Basidiomycetes). II. Windahlia 17: 43-48.

-. 1988. Species delimitation in Corticiaceae (Basidiomycetes). Mycotaxon 31: 445-465.

-, Hjortstam, K. 1989. *Hypochnicium erikssonii* sp. nov. instead of *H. sphaerosporum* - a necessary name alternation. Windahlia 18: 43-46.

-, Larsson, E. 1991. Differences in culture characters and electrophoretic patterns between sibling species in four different species complexes (Corticiaceae, Basidiomycetes). Mycologia 83 (in press).

Hjortstam, K., Larsson, K-H., and Ryvarden, L. 1988. The Corticiaceae of North Europe. Vol. 8. Pp. 1450-1631. Fungiflora, Oslo.

Hjortstam. K., Ryvarden, L. Notes on Corticiaceae (Basidiomycetes). IV. Mycotaxon 9: 505-19.

Kotlaba, F. 1976. Contribution to the knowledge of the Turkish Macromycetes. Ceska Mykol. 30: 156-169.

Lemke, P. A. 1969. A reevaluation of homothallism, heterothallism and the species concept in *Sistotrema brinkmannii*. Mycologia 61: 57-76.

Macrae, R. 1966. Pairing incompatibility and other distinctions among *Hirschioporus* (*Polyporus*) *abietinus*, *H. fusco-violaceus*, and *H. laricinus*. Can. J. Bot. 45: 1371-98.

Magasi, L. P. 1976. Incompatibility factors in *Polyporus abietinus*, their numbers and distribution. Mem. New York Bot. Gard. 28 (1): 163-73.

Mounce, I., Macrae, R. 1938. Interfertility phenomena in *Fomes pinicola*. Can. J. Res. C. 16: 354-76.

Nakasone, K. K. 1982. Cultural and morphological studies of *Gloeocystidiellum porosum* and *Gloeocystidiellum clavuligerum*. Mycotaxon 14: 316-24.

Niemelä, T. 1987. The raduloid species of *Schizopora*. Beiträge zur Kenntnis der Pilze Mitteleuropas. 3: 365-70. Arbeitsgemeinschaft Mykologie Ostwürttemberg (AMO).

Niemelä, T., Uotila, P. 1977. Lignicolous macrofungi from Turkey and Iran. Karstenia 17: 33-39.

Quézel, P. 1986. The forest vegetation of Turkey. Proc. Royal Soc. Edinburgh 89 B: 113-22.

Robak, H. 1942. Cultural studies in some Norwegian wood-destroying fungi. Meddelelse Vestl. Forst. 7: 1-248.

Ryvarden, L. 1978. The Polyporaceae of North Europe. Vol. 2. Pp. 219-507. Fungiflora, Oslo.

Saliba, J., David, A. 1988. Apports des caractères culturaux et des confrontations dans l'étude des représentants européens du genre *Steccherinum* (Basidiomycètes, Aphyllophorales). Cryptogamie Mycol. 9 (2): 93-110.

Takhtajan, A. 1969. Flowering plants. Origin and dispersal. Pp. 1-310. Oliver & Boyd, Edinburgh.

Telleria, M. T. 1990. Annotated list of the Corticiaceae, sensu lato (Aphyllophorales, Basidiomycotina), for Peninsular Spain and Balearic Islands. Bibliotheca Mycologica 135: 1-152. Cramer, Berlin & Stuttgart.

Ullrich, R. C. 1973. Sexuality, incompatibility, and intersterility in the biology of the *Sistotrema brinkmannii* aggregate. Mycologia 65: 1234-49.

Zohary, M. 1973. Geobotanical foundations of the Middle East. Vol. 1. Pp. 1-340. Gustav Fischer, Stuttgart.

MYCOTAXON

Volume XLII, pp. 387-504 October-December 1991

DESCRIPTION AND IDENTIFICATION OF CULTURES OF ECTOMYCORRHIZAL FUNGI FOUND IN NORTH AMERICA

LEONARD J. HUTCHISON*

Department of Botany, University of Toronto,
25 Willcocks Street, Toronto, Ontario CANADA M5S 3B2

ABSTRACT

Dichotomous and synoptic keys are provided and descriptions given for cultures of 96 species of ectomycorrhizal fungi likely to be found in temperate North America. The key characters employed are physiological and biochemical in nature and involve the use of simple tests for determining enzymatic degradation of selected carbon and nitrogen compounds, tolerances to selected fungitoxic compounds and standard extreme temperatures, detection of polyphenol oxidase activity and reactions of mycelia to diazonium blue B staining; additional characters include both macro- and micromorphological features of the colonies and host associations.

RÉSUMÉ

Des clés dichotomiques et synoptiques, de même qu'une description des cultures de 96 espèces de champignons ectomycorhiziens de la zone tempérée de l'Amerique du Nord sont fournis. Les principaux caractères employès dans les clés sont de nature physiologique et biochimique. Ils nécessitent l'utilisation de tests simple pour la détermination du potentiel de degradation enzymatique de composés de carbone et d'azote sélectionnés, de la tolérance à certaines substances fungitoxiques, de l'activité de la polyphénol oxidase, ou de la réaction du mycélium au bleu de diazonium B. On a également utilisé des caractères macro- et micromorphologiques, ainsi que les données quant à l'identité de l'essence-hôte.

INTRODUCTION

The development of the in vitro mycorrhizal synthesis technique by Elias Melin (1922, 1923a, 1923b, 1924) demonstrated that many fungi, particularly among the Hymenomycetes (e.g. Agaricales, Aphyllophorales) could form ectomycorrhizae with a variety of temperate tree species (e.g. Pinaceae, Betulaceae, Salicaceae). However, while over 5,000

---

* Present address: Department of Forest Science, University of Alberta, Edmonton, Alberta, CANADA T6G 2H1.

species of fungi are either known to be or are suspected of being ectomycorrhizal (Malloch et al. 1980), the identification of these fungal symbionts from field collected ectomycorrhizae is still virtually impossible. Dominik (1969), and later Haug et al. (1986, 1987) classified ectomycorrhizae based on morphological and anatomical features and assigned letter or numerical designations to the different types without knowing which fungi were involved. Zak (1971) and Agerer (1987) have adopted the same strategy to classify ectomycorrhizae but by tracing hyphal connections between basidiomata and particular types of ectomycorrhizae, they have been able to name the fungal symbionts involved. McArdle (1931) pointed out however, that such methods were not always reliable. Therefore it would be preferable to isolate the fungal symbionts and obtain a positive identification based on cultural studies as attempted by Chu-Chou and Grace (1983a, 1983b).

While good cultural descriptions are available for many species of wood-decaying Hymenomycetes (e.g. Davidson et al. 1942; Nobles 1948; van der Westhuizen 1958; Stalpers 1978), cultural descriptions exist for only a limited number of ectomycorrhizal species (e.g. Modess 1941; Sobotka 1954; Mikola 1955; Pantidou and Groves 1966; Kowalski 1974; Miller et al. 1983; Wolfe 1989; Besl et al. 1989). Many species are remarkably similar in cultural morphology and are difficult to differentiate and identify when isolated from field-collected ectomycorrhizae (e.g. Zak and Bryan 1963; Zak and Marx 1964; Pachlewski 1967; Lamb and Richards 1970; Peña-Cabriales and Valdés-Hgo 1974; Chu-Chou 1979; Chu-Chou and Grace 1981a, 1982, 1987, 1988; Danielson 1984; Danielson and Pruden 1989; Schild et al. 1987). A lack of informative morphological characters among ectomycorrhizal fungi such as conidial anamorphs (Hutchison 1989) have lead Hutchison and Malloch (1988) to suggest the need to use an integrated approach involving physiological and biochemical characters in addition to morphological ones. Such an integrated approach as provided here in this present paper allows for the identification of cultures of 96 species of ectomycorrhizal fungi from North America.

MATERIALS AND METHODS

All fungal strains used in this study were cultured from tissue pieces aseptically derived from the interior of fresh basidiomata, except for the strains of Cenococcum geophilum which were isolated from serially washed mycorrhizal root tips. Tissue pieces were placed on modified BAF agar (described below) supplemented with 2mg/L of chlortetracycline hydrochloride (Sigma Chemical Co., St.Louis, Missouri, USA), 30 mg/L of streptomycin sulphate, and 2mg/L of benomyl (Belate, 50% wettable powder, Du Pont Co., Wilmington, Delaware, USA). These cultures have been deposited into the University of Alberta Microfungus Collection (UAMH), with dried basidiomata and notes deposited into the University of Toronto Cryptogamic Herbarium (TRTC). Additional isolates were obtained from UAMH, Centre de recherche en biologie forestière (CRBF), American Type Culture Collection (ATCC), and Centraalbureau voor Schimmelcultures (CBS).

For comparative purposes, all isolates were inoculated onto four different agar media: (1) potato dextrose agar (BBL, Becton Dickinson and Co., Cockeysville, Maryland, USA), (2) a modification of BAF agar

(Moser 1960) [glucose 30.0 g; peptone 2.0 g; yeast extract 1.0 g; potassium phosphate monobasic 0.5 g; magnesium sulphate 0.5 g; calcium chloride 0.1 g; ferric chloride (1% sol'n) 1.0 mL aliquot; zinc sulphate (0.1% sol'n) 1.0 mL aliquot; manganese sulphate (0.5% sol'n) 1.0 mL aliquot; agar 15.0 g; distilled water 1000 mL], (3) a modification of modified Melin-Norkrans agar (Marx 1969) [glucose 5.0 g; malt extract 2.0 g; yeast extract 1.0 g; potassium phosphate monobasic 0.5 g; ammonium phosphate dibasic 0.25 g; magnesium sulphate 0.15 g; calcium chloride (1% sol'n) 5 mL aliquot; sodium chloride (1% sol'n) 2.5 mL aliquot; ferric chloride (1% sol'n) 1.2 mL aliquot; agar 15.0 g; distilled water 1000 mL], and (4) a modification of modified Hagem's agar (Modess 1941) [glucose 5.0 g; malt extract 5.0 g; yeast extract 1.0 g; potassium phosphate monobasic 0.5 g; ammonium chloride 0.5 g; magnesium sulphate 0.5 g; ferric chloride (1% sol'n) 0.5 mL aliquot; agar 15.0 g; distilled water 1000 mL]. These agar media were autoclaved for 30 minutes and poured into standard (90 mm) plastic petri dishes (30 mL/dish). Inoculation plugs for each fungal isolate were cut out from the margins of young colonies using a sterilized cork borer, resulting in discs 4 mm in diameter. These were placed mycelium side down in the centre of each agar plate in triplicate. The plates were sealed with parafilm (American Can Co., Greenwich, Connecticut, USA) and incubated upside down in the dark at 18°C for 35 days. Measurements of growth were made at this time and descriptions of colony morphology were made using the terminology of Stalpers (1978). Colour descriptions were after Kornerup and Wanscher (1978). Both aerial and submerged mycelium from colonies grown on the four agar media were mounted in a 1% aqueous solution of phloxine (Largent et al. 1977) and examined microscopically. Physiological and biochemical tests follow the methodologies outlined by Hutchison and Summerbell (1990) and Hutchison (1990a, 1990b, 1990c, 1990d).

Taxonomy generally follows Singer (1986) for Agaricales, Donk (1964) for Aphyllophorales and Hawksworth et al. (1981) for the Gasteromycetes.

SUMMARY OF DIAGNOSTIC CHARACTERS EMPLOYED

A. PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS

1. Enzymatic degradation of selected carbon and nitrogen compounds (Hutchison 1990a).

a. cellulose, lignin and pectin degradation - not detectable in ectomycorrhizal fungi, although pectin degradation could be weakly detected in some species.
b. lipid degradation - present among species of Amanita and Leccinum.
c. amylose degradation - present among most species of Amanita and Cortinarius.
d. gelatin degradation - present among species of Lactarius section Dapetes.
e. casamino acids degradation - present among species of Laccaria and Hebeloma.
f. acidification of BCP-casamino acids agar after 12 weeks - present among species of Lactarius, Cortinarius and Amanita.
g. urea degradation with concomitant growth - characteristic for

Laccaria and *Hebeloma*.
h. lack of urea degradation but exhibiting growth - present for the genera *Amanita*, *Boletinus*, *Rhizopogon* and *Hygrophorus*.
i. urea degradation with lack of growth - found among species of *Scleroderma*, most species of *Lactarius* and several boletes.
j. lack of urea degradation and lack of growth - sporadic but found among some species of *Lactarius*, *Cortinarius* and *Suillus*.

2. Effect of standard extreme temperatures upon linear growth (Hutchison 1990d).
a. growth semi-tolerant to tolerant (>20% of controls (18°C)) at 7°C - diagnostic for most species of *Laccaria* and *Hebeloma*.
b. growth semi-tolerant to tolerant (>20% of controls (18°C)) at 30°C - found among species of *Amanita*, *Laccaria*, *Suillus*, *Rhizopogon*, *Pisolithus* and *Scleroderma*.

3. Effect of fungitoxicants upon linear growth (Hutchison 1990c).
a. growth tolerant (>50% of controls) to benomyl (10ug/mL) - found among all members of the Boletaceae and most *Cortinarius* species.
b. growth sensitive (<20% of controls) to benomyl (10ug/mL) - characteristic for species of *Hebeloma* and *Lactarius*.
c. growth tolerant (>50% of controls) to cycloheximide (2ug/mL) - found among *Laccaria*, *Rhizopogon* and most species of *Hebeloma*.
d. growth sensitive (<20% of controls) to cycloheximide (2ug/mL) - present among *Leccinum*, *Lactarius* and *Suillus* species.
e. growth tolerant (>50% of controls) to rose bengal (10ug/mL) - found among species of *Cortinarius*, *Laccaria* and *Suillus*.
f. growth sensitive (<20% of controls) to rose bengal (10ug/mL) - found among species of *Hygrophorus*, and many *Lactarius*.
g. growth tolerant (>50% of controls) to malachite green (2ug/mL) - present in species of *Suillus* and *Tricholoma*.
h. growth sensitive (<20% of controls) to malachite green (2ug/mL) - found among species of *Lactarius*.
i. growth tolerant (>50% of controls) to sodium chloride (10mg/mL) - exhibited by most species of *Suillus*, *Laccaria* and *Hebeloma*.
j. growth sensitive (<20% of controls) to sodium chloride (10mg/mL) - characteristic for *Xerocomus*, *Rhizopogon*, *Hygrophorus* and most species of *Tricholoma*.

4. Polyphenol oxidase activity (Hutchison 1990b).
a. laccase dominant - characteristic for species of *Tricholoma* subgenus Tricholoma section Tricholoma.
b. tyrosinase dominant - characteristic for *Leccinum*, *Amanita*, *Laccaria*, *Scleroderma* and most species of *Rhizopogon*.
c. equivalent for laccase and tyrosinase - found among most *Lactarius* species.
d. negative for laccase and tyrosinase - characteristic for *Paxillus*, *Suillus*, and most species of *Tricholoma* subgenus Tricholoma section Genuina.

5. Diazonium blue B staining reaction of mycelia (Hutchison and Summerbell 1990).
a. red staining of mycelium pre-treated with KOH hydrolysis - characteristic for Basidiomycetes, while Ascomycetes tend to be negative.
b. red staining reaction without pre-treatment - mainly restricted to a few species within both the Boletaceae and the genus *Lactarius*.
c. yellow staining reaction without pre-treatment - found among species

of Hebeloma, Hygrophorus, Laccaria and Tricholoma.

d. negative reaction without pre-treatment - found among species of Cortinarius and most boletes.

B. MACROMORPHOLOGICAL CHARACTERISTICS

1. Growth rate

Variable for various species, but as a rule growth rarely exceeds 70 mm in 5 weeks. Certain genera such as Russula and Cortinarius grow very slowly over this time period. Species tend to grow slower on modified BAF agar and PDA than on modified MN agar and modified Hagem's agar.

2. Texture and outline of colonies

Diagnostic for certain taxonomic groups. Most species possess colonies which exhibit cottony growth and are circular in outline (e.g. Amanita, Hebeloma, Tricholoma, and most boletes) while colonies of several others may be appressed (e.g. Rozites caperata, Lactarius vinaceorufescens). A number of species are characteristically very funiculose and irregular in outline (e.g. Lactarius section Dapetes). The agar medium frequently influences the degree to which species exhibit particular characteristics.

3. Colour of colonies

Most cultures are white but several produce distinct colours. Cenococcum geophilum is jet black while Piloderma bicolor exhibits a distinctive lemon yellow colour. Colour can be ephemeral such as in several Cortinarius species exhibiting violaceous colours when young but reverting to white after 5 weeks (e.g. C.allutus, C.amoenolens, C.anomalus, C.glaucopus). Some media may promote colouration while others inhibit it (e.g. Laccaria bicolor is violet on all media except PDA where it is generally white).

4. Pigmentation of agar

Many ectomycorrhizal fungi characteristically exude pigments into the agar particularly on BAF and PDA but less so or not at all on MN and Hagem's. The Boletaceae and their gasteroid relatives exude dark brown phenolic pigments into the agar while Cortinarius brunneus characteristically exudes intense yellow pigments. Several species may exude pigment which are noticeable only after incubation periods longer that 5 weeks e.g. Lactarius hibbardae, Tricholoma fulvum and T.focale.

C. MICROMORPHOLOGICAL CHARACTERISTICS

1. Clamp connections

The presence of clamp connections is one of the more reliable and useful morphological taxonomic characters found in cultures of basidiomycetous ectomycorrhizal fungi. Within species of certain genera, clamp connections may be consistently absent (Figs. 1-3) (e.g. Lactarius) or very rarely present (e.g. Suillus, Tricholoma) while species of other genera consistently possess them at every septum (Figs. 4-8) such as Hygrophorus, Laccaria, Hebeloma, Boletinus, most Cortinarius species and Paxillus. The presence or absence of clamps in a culture reflects their presence or absence in the corresponding basidiomata. This observation which was first made by Nobles (1971) is referred to here as **NOBLES' RULE**: if basidiomata possess clamp connections so too will their corresponding dikaryotic cultures.

However, in some cases, dedikaryotization of hyphae may spontaneously occur after several transfers, resulting in clampless monokaryons (James Ginns, personal communication). Such a phenomenon may be induced due to the autoclaving of glucose and natural products such as malt extract incorporated into the agar media resulting in the release of particular compounds (Dickhardt 1985). Clampless cultures of known clamped species were encountered in this study among isolates of _Paxillus involutus_, _Alpova diplophloeus_, _Rozites caperata_, _Scleroderma bovista_ and _S.arenicola_.

Clamp connections may be simple (Fig. 5) or doughnut-shaped (Figs. 4,6-8), although a few abnormalities may exist (Fig. 9). In some cases incomplete or pseudoclamps are found (Figs. 10-12). Multiple clamps may exist at branches referred to as "paarige" branching (Melin 1923a) (Figs. 13-14). In _Amanita muscaria_, clamp connections occur only in the older portions of the hyphae but are absent in the younger portions. This phenomenon is referred to as being astatocoenocytic (Boidin 1971).

2. Morphological differentiation of hyphae

a. Swellings are commonly produced. They frequently have been misinterpreted as chlamydospores or in some cases as conidia (Hutchison 1989). These may be induced as the hyphae age and may be more frequent on one medium than on another for any given species. Swellings may be terminal (Figs. 15-17) but are more commonly intercalary (Figs. 18-20). These never break away and are always thin walled and hyaline.

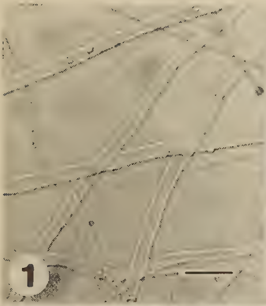
b. Funiculose cords (Fig. 24) consist of aggregations of aerial hyphae. These are characteristically produced by species of _Lactarius_ section Dapetes and _Laccaria_ species although many other species such as _Cortinarius brunneus_ may produce them.

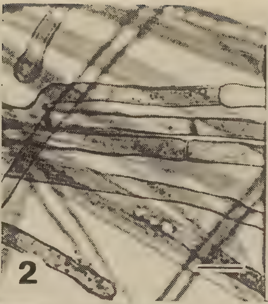
c. Hyphal threads (Fig. 23) consist of long threads of aerial hyphae which generally occur appressed on the surface of the colony. _Xerocomus badius_ and a number of boletaceous fungi and their gasteroid allies tend to produce such structures.

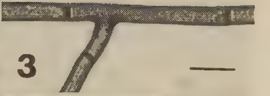
d. Hyphal coils (Figs. 25-26) are irregularly produced among various species but are most common among species of _Laccaria_ and _Hydnangium_.

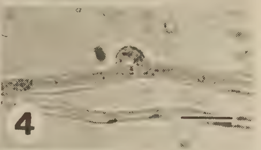
e. Pigmentation of hyphae - most fungi examined possess hyaline hyphae. Notable exceptions include _Cenococcum geophilum_ and _Strobilomyces floccopus_ which are darkly pigmented.

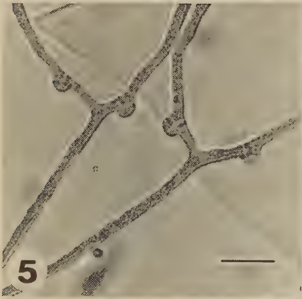
FIGS. 1-3. Hyphae of ectomycorrhizal fungi lacking clamp connections (scale = 10um). Fig. 1. _Lactarius mucidus_ UAMH 6076. Fig. 2. _Strobilomyces floccopus_ LH-17-86. Fig. 3. _Cenococcum geophilum_ UAMH 6080. FIGS. 4-9. Hyphae of ectomycorrhizal fungi with clamp connections (scale = 10um). Fig. 4. _Cortinarius mucidus_ UAMH 5837. Fig. 5. _Laccaria ochropurpurea_ UAMH 5814. Fig. 6. _Laccaria proxima_ UAMH 6062. Fig. 7. _Laccaria laccata_ UAMH 6063. Fig. 8. _Scleroderma citrinum_ UAMH 5935. Fig. 9. Abnormal clamp formation in _Laccaria laccata_ UAMH 6063. FIGS. 10-12. Incomplete clamp connections (scale = 10um). Fig. 10. _Cortinarius brunneus_ UAMH 5793. Fig. 11. _Paxillus involutus_ UAMH 6156. Fig. 12. _Thelephora terrestris_ UAMH 5931. FIGS. 13-14. "Paarige" branching with multiple clamp connections (scale = 10um). Figs. 13-14. _Scleroderma citrinum_ UAMH 5935.

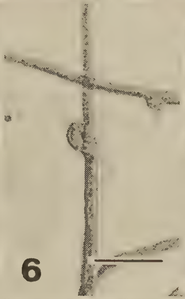

1

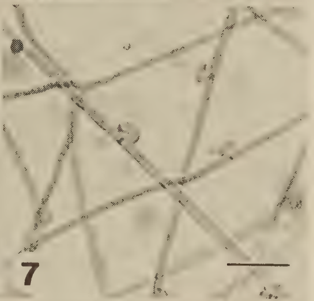

2

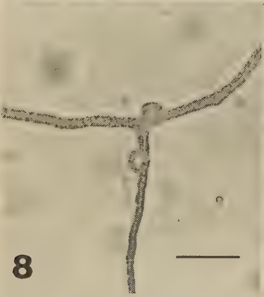

3

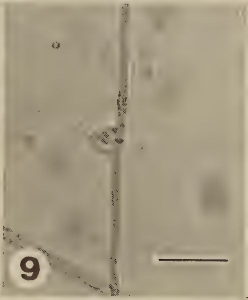

4

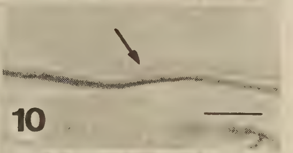

5

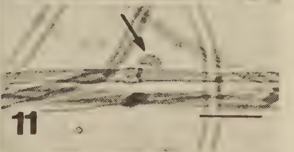

6

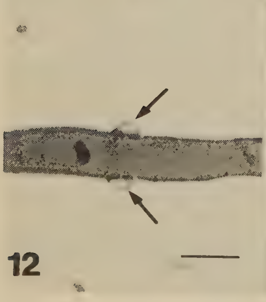

7

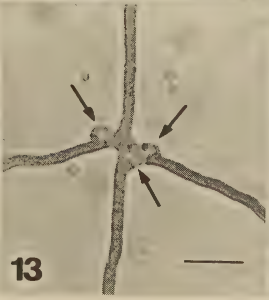

8

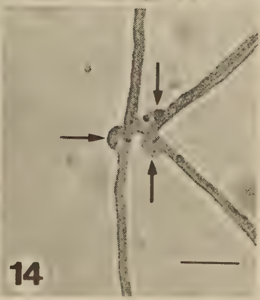

9


10


11


12


13


14

f. Oleiferous hyphae (Fig. 21) and encrusted hyphae (Fig. 22) are occasionally found among ectomycorrhizal fungi but possess no taxonomic value. Oleiferous hyphae are filled with lipid materials which impart a different refractive index to them as compared to the adjacent vegetative hyphae. Encrusted hyphae are usually found associated with submerged hyphae of those fungi which release brown phenolic pigments into the agar. The crystals generally consist of aggregations of calcium oxalate.

D. ECOLOGICAL CHARACTERISTICS

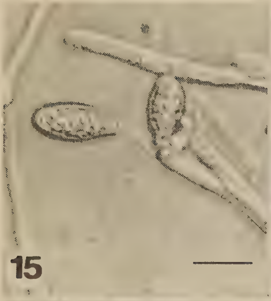
1. Host association

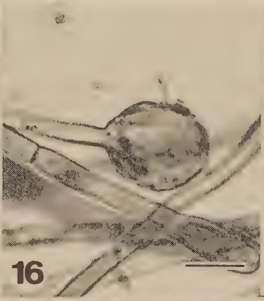
Although host associations were not investigated during this study, it is important to recognize that many species are host specific. Most data is taken from the literature (e.g. Moser 1983; Snell and Dick 1970; Miller 1980). Many species are known to possess a broad host range (e.g. Cenococcum geophilum, Amanita muscaria and Laccaria laccata) while others are restricted to either coniferous forests (e.g. Boletus edulis) or deciduous forests (e.g. Tricholoma resplendens). Other species still are very host specific (e.g. Truncocolumella citrina with Pseudotsuga menziesii, Laccaria ochropurpurea with Quercus, Suillus grevillei with Larix, Alpova diplophloeus with Alnus, Leccinum holopus with Betula).

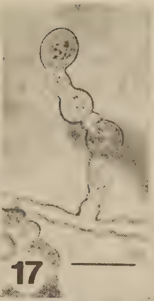
2. Geographic distribution

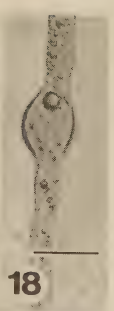
Most species examined in this present study are circumboreal in distribution and may be found throughout the forested regions of North America and Eurasia. However, many species are indigenous to North America and among these, several are restricted in range to particular regions (e.g. Boletus ornatipes, Lactarius subpurpureus to eastern North America and Suillus umbonatus, Rhizopogon vinicolor to western North America). This restriction is the result of specific host associations (recently discussed by Redhead 1989). Other species still are common in the south but absent to very rare in the north (e.g. Pisolithus arhizus) or are common in the north but absent from the south (e.g. Suillus tomentosus).

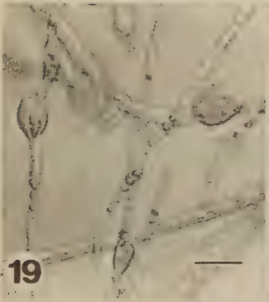
FIGS. 15-20. Swellings on hyphae of ectomycorrhizal fungi (scale = 10um) (Figs. 15-16 & 19 courtesy of Mycologia, from Hutchison 1989). Fig. 15. Terminal swellings on hyphae of Cortinarius anomalus DM 95. Fig. 16. Terminal swellings on hyphae of Strobilomyces floccopus LH-17-86. Fig. 17. Terminal swelling on hypha of Thelephora terrestris UAMH 5931. Fig. 18. Intercalary swelling on hypha of Suillus grevillei UAMH 5924. Fig. 19. Intercalary swellings on hyphae of Laccaria bicolor UAMH 6061. Fig. 20. Intercalary swellings on hyphae of Amanita muscaria UAMH 6142. FIGS. 21-26. Other hyphal characters found among ectomycorrhizal fungi (scale = 10um except for fig. 24 where scale = 250um). Fig. 21. Oleiferous hyphae of Suillus brevipes UAMH 6159. Fig. 22. Encrustations on hypha of Suillus neoalbidipes UAMH 6158. Fig. 23. Hyphal strand of Suillus luteus UAMH 6058. Fig. 24. Funiculose cord of Laccaria proxima UAMH 6062. Fig. 25. Hyphal coil of Laccaria bicolor UAMH 6061. Fig. 26. Hyphal coil of Lactarius torminosus UAMH 5815.

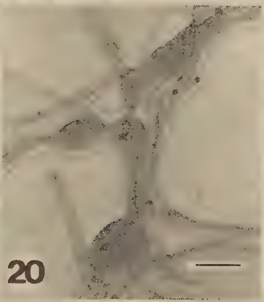

15

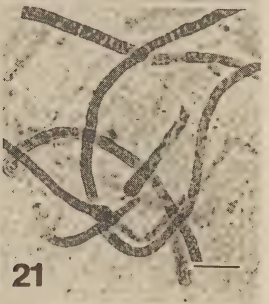

16

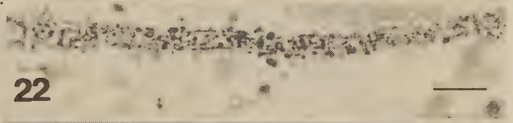

17

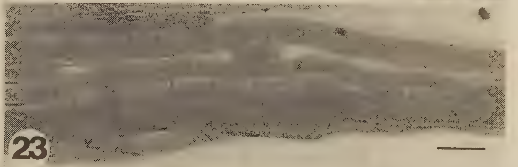

18

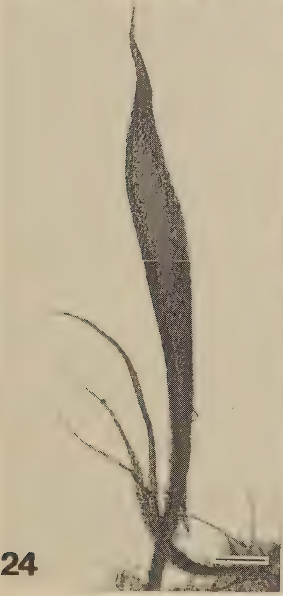

19

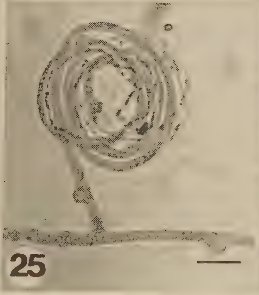

20

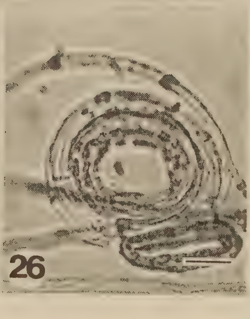

21


22


23


24


25


26

3. Specialized habitat

All species studied may be considered as terricolous, however, several species in addition may be found forming ectomycorrhizae in rotting wood (e.g. *Xerocomus subtomentosus* and *Scleroderma citrinum*). Some species are characteristic of tree nurseries and are frequently referred to as "early stage colonizers" (e.g. *Laccaria*, *Hebeloma*, *Thelephora*), while other species are characteristic of mature forests (e.g. *Lactarius* and *Russula*) which are referred to as "late stage colonizers". There are species which are found only in moist habitats (e.g. *Suillus glandulosus*), and others which are only found in dry habitats (e.g. *Bankera fuligineo-alba*). Again, this is generally a reflection of close host associations.

DICHOTOMOUS KEY TO THE *IN VITRO* IDENTIFICATION OF ECTOMYCORRHIZAL FUNGI ISOLATED FROM FIELD COLLECTED ECTOMYCORRHIZAE*

1. Colonies exhibiting one of the following characteristics: (a) cellulose degradation, (b) lignin degradation, (c) strong pectinase activity, (d) production of conidia, (e) very rapid growth rate (>90 mm in 14 days) ......non-ectomycorrhizal species

1. Colonies not exhibiting any of the above characteristics 2

    2. Colonies sensitive to benomyl (1ug/mL), and/or possessing mycelia which, when pre-treated with KOH hydrolysis fail to stain red with diazonium blue B, and always lacking clamp connections 3

    2. Colonies tolerant to benomyl (1ug/mL), and possessing mycelia which, when pre-treated with KOH hydrolysis, stain red with diazonium blue B and/or having clamp connections present/absent on the hyphae 4

3. Colonies jet black and felty .... 96. *Cenococcum geophilum*

3. Colonies other colours ....ascomycetous species (e.g. *Tuber*, *Elaphomyces*, not covered in this present study).

    4. Colonies always having the following three features: (1) exuding brown pigments into agar (BAF and PDA) *and* (2) tolerant (growth >50% of controls) to benomyl (10ug/mL) *and* (3) lacking laccase 5

    4. Colonies having one or two of the above characters but not *all* three 41

5. Clamp connections present at all or most septa 6

5. Clamp connections absent or very rare 14

    6. Growth semi-tolerant to tolerant (>20% of controls) at 30°C 7

    6. Growth sensitive (<20% of controls) at 30°C 12

7. Tyrosinase present 8

7. Tyrosinase absent 10

---

*NOTE: if a clampless isolate cannot be keyed out, assume it has clamps and start through key at the beginning. Isolates from field collected ectomycorrhizae may be monokaryons of otherwise clamped species. Clamped isolates may spontaneously undergo dedikaryotization soon after isolation.

8. Growth sensitive (<20% of controls) to sodium chloride (10mg/mL) ....85. *Scleroderma citrinum*
8. Growth semi-tolerant to tolerant (>20% of controls) to sodium chloride (10mg/mL) 9
9. Growth semi-tolerant to tolerant (>20% of controls) to cycloheximide (2ug/mL) ....84. *Scleroderma arenicola*
9. Growth sensitive (<20% of controls) to cycloheximide (2ug/mL) ....86. *Scleroderma bovista*
10. Degradation of urea (growth absent) ..87. *Pisolithus arhizus*
10. Negative for urea degradation (+growth) 11
11. Restricted to *Larix laricina*, eastern North America ....4. *Boletinus paluster*
11. Wide host range throughout North America ..28. *Paxillus involutus*
12. Tyrosinase present and/or positive for degradation of casamino acids and restricted to *Alnus* ....92.*Alpova diplophloeus*
12. Tyrosinase absent and negative for casamino acids degradation and found on other hosts 13
13. Restricted to *Larix* ....3. *Boletinus cavipes*
13. Also found on other hosts ....28. *Paxillus involutus*
14. Growth semi-tolerant to tolerant (>20% of controls) to sodium chloride (10mg/mL) 15
14. Growth sensitive (<20% of controls) to sodium chloride (10mg/mL) 33
15. Broad-leaved hosts 16
15. Coniferous hosts 17
16. Associated with *Quercus* ....2. *Boletellus russellii*
16. Associated with *Betula* ....27. *Leccinum holopus*
17. Growth semi-tolerant to tolerant (>20% of controls) at 30°C .. 18
17. Growth sensitive (<20% of controls) at 30°C 30
18. Associated with *Larix* 19
18. Associated with *Pinus* 21
19. Non-treated mycelia failing to stain with diazonium blue B ....9. *Suillus grevillei*
19. Non-treated mycelia staining red with diazonium blue B 20
20. Associated with *Larix occidentalis*, western North America ....12. *Suillus ochraceoroseus*
20. Associated with *Larix laricina*, eastern North America ....14. *Suillus spectabilis*
21. Non-treated mycelia staining yellow with diazonium blue B 22
21. Non-treated mycelia staining red or failing to stain with diazonium blue B 24
22. Clamp connections never found, associated only with *Pinus banksiana* and *P.contorta* ....17. *Suillus tomentosus*
22. Infrequent presence of clamp connections, associated with *Pinus strobus* or other pines 23
23. Associated only with *Pinus strobus*, eastern North America ....5. *Suillus americanus*
23. Associated with other pines in addition to *P.strobus*, throughout North America ....8. *Suillus granulatus*
24. Acidification of BCP-casamino acids agar after 12 weeks ....18. *Suillus umbonatus*
24. Negative for acidification of BCP-casamino acids agar ... 25

25. Non-treated mycelia staining red with diazonium blue B ....10. *Suillus luteus*

25. Non-treated mycelia failing to stain with diazonium blue B ... 26

26. Degradation of urea (without growth) 27

26. Negative for degradation of urea (with growth) 28

27. Restricted to *Pinus banksiana*, eastern North America ....16. *Suillus subluteus*

27. Associated with 2- and 3-needle pines throughout North America ....6. *Suillus brevipes*

28. Colonies felty-cottony appressed, radially lacunose, tyrosinase present ....91. *Rhizopogon vulgaris*

28. Colonies cottony, not radially lacunose, tyrosinase absent 29

29. Restricted to *Pinus strobus*, eastern North America ....15. *Suillus spraguei*

29. Found on other pine species in addition to *P. strobus*, throughout North America ....11. *Suillus neoalbidipes*

30. Associated with *Larix* 31

30. Associated with other coniferous hosts 32

31. Tyrosinase present ....19. *Suillus viscidus*

31. Tyrosinase absent ....9. *Suillus grevillei*

32. Acidification of BCP-casamino acids agar and associated with *Pinus contorta*, western North America ....18. *Suillus umbonatus*

32. Negative for acidification of BCP-casamino acids agar and associated with *Picea* and *Abies*, eastern Canada and adjacent USA ....7. *Suillus glandulosus*
13. *Suillus sinuspaulianus*

33. Growth semi-tolerant to tolerant (>20% of controls) at 30°C .. 34

33. Growth sensitive (<20% of controls) at 30°C 36

34. Tyrosinase absent, colonies brown ....82. *Coltricia perennis*

34. Tyrosinase present, colonies whitish 35

35. Associated with 2- and 3-needled pines, common throughout North America ....88. *Rhizopogon rubescens*

35. Associated with wider range of *Pinus* spp., less commonly found throughout North America ....89. *Rhizopogon superiorensis*
91. *Rhizopopgon vulgaris*

36. Degradation of lipid ....24. *Boletus ornatipes*

36. Negative for lipid degradation 37

37. Degradation of amylose ....22. *Chalciporus piperatus*

37. Negative for amylose degradation 38

38. Tyrosinase present 39

38. Tyrosinase absent 40

39. Degradation of casamino acids, occurring in eastern North America ....20. *Xerocomus badius*

39. [+]Negative for degradation of casamino acids, associated with *Pseudotsuga menziesii*, western North America ....93. *Truncocolumella citrina*

40. Non-treated mycelia staining red with diazonium blue B, wide host range throughout North America ....21. *Xerocomus subtomentosus*

40. Non-treated mycelia not staining with diazonium blue B, associated with *Pseudotsuga menziesii*, western North America ....90. *Rhizopogon vinicolor*

41. Clamp connections always present at every septum (present in older hyphae of *Amanita muscaria*) 42
41. Clamp connections absent or very rare (or with pseudoclamps) . 70
    42. Growth semi-tolerant to tolerant (>20% of controls) to benomyl (10ug/mL) 43
    42. Growth sensitive (<20% of controls) to benomyl (10ug/mL). 62
43. Brown pigments diffusing into agar (BAF and PDA), associated with *Alnus* ....92. *Alpova diplophloeus*
43. Brown pigments not produced 44
    44. Growth semi-tolerant to tolerant (>20% of controls) to sodium chloride (10mg/mL) 45
    44. Growth sensitive (<20% of controls) to sodium chloride (10mg/mL) 56
45. Growth semi-tolerant to tolerant (>20% of controls) at 30°C .. 46
45. Growth sensitive (<20% of controls) at 30°C 52
    46. Degradation of urea (with growth) 47
    46. Negative for urea degradation (±growth) 51
47. Growth semi-tolerant to tolerant (>20% of controls) at 7°C ... 48
47. Growth sensitive (<20% of controls) at 7°C 50
    48. Colonies violet ....31. *Laccaria bicolor*
    48. Colonies white 49
49. Colonies entirely white ....32. *Laccaria laccata*
49. Colonies white with violet tufts on colonies (BAF and PDA) developing with age ....34. *Laccaria proxima*
    50. Associated with *Quercus*, eastern North America ....33. *Laccaria ochropurpurea*
    50. Associated with *Eucalyptus*, in California, Oregon and Florida ....95. *Hydnangium carneum*
51. Degradation of lipid ....50. *Amanita muscaria*
51. Negative for lipid degradation ....95. *Hydnangium carneum*
    52. Tyrosinase present 53
    52. Tyrosinase absent 55
53. Negative for amylose degradation ....50. *Amanita muscaria*
53. Degradation of amylose 54
    54. Degradation of gelatin ....58. *Cortinarius amoenolens*
    54. Negative for gelatin degradation ....63. *Cortinarius subpurpurascens*
55. Degradation of gelatin ....57. *Cortinarius allutus*
55. Negative for gelatin degradation ....61. *Cortinarius glaucopus*
    56. Growth semi-tolerant to tolerant (>20% of controls) at 30°C 57
    56. Growth sensitive (<20% of controls) at 30°C 59
57. Degradation of urea (with growth) ....80. *Thelephora terrestris*
57. Negative for urea degradation (±growth) 58
    58. Colonies white and cottony, wide host range ....50. *Amanita muscaria*
    58. Colonies hyaline to yellowish white, appressed, associated only with *Pinus* ....62. *Cortinarius mucosus*
59. Degradation of lipid 60
59. Negative for lipid degradation 61
    60. Tyrosinase present ....50. *Amanita muscaria*
    60. Tyrosinase absent ....64. *Rozites caperata*

61. Associated with broad-leaved hosts, tolerant (>50% of controls) to malachite green (2ug/ml) *and* with strong production of laccase ....30. *Hygrophorus russula*

61. Associated with coniferous hosts, sensitive (<20% of controls) to malachite green (2ug/mL) *and* weak to negative for laccase activity ....29. *Hygrophorus eburneus*

62. Growth semi-tolerant to tolerant (>20% of controls) to sodium chloride (10mg/mL) 63

62. Growth sensitive (<20% of controls) to sodium chloride (10mg/mL) 67

63. Degradation of lipid *and* non-treated mycelia not staining with diazonium blue B ....50. *Amanita muscaria*

63. Negative for lipid degradation *and* non-treated mycelia staining yellow with diazonium blue B 64

64. Degradation of amylose ....52. *Hebeloma crustuliniforme*

64. Negative for amylose degradation 65

65. Laccase absent ....53. *Hebeloma cylindrosporum*

65. Laccase present 66

66. Associated with coniferous hosts *and* tyrosinase present when grown on most media ....54. *Hebeloma longicaudum*

66. Associated with broad-leaved hosts *and* tyrosinase never present when grown on all media ......56. *Hebeloma velutipes*

67. Negative for lipid degradation 68

67. Positive for lipid degradation 69

68. Growth semi-tolerant (>20% of controls) at 7°C *and* negative for gelatin degradation; colonies cottony and brown ....55. *Hebeloma mesophaeum*

68. Growth sensitive (<20% of controls) at 7°C *and* positive for degradation of gelatin; colonies appressed and yellowish white ....62. *Cortinarius mucosus*

69. Degradation of amylose, tyrosinase absent ....60. *Cortinarius brunneus*

69. Negative for amylose degradation, tyrosinase present ....50. *Amanita muscaria*

70. Growth semi-tolerant to tolerant (>20% of controls) to benomyl (10ug/mL) 71

70. Growth sensitive (<20% of controls) to benomyl (10ug/mL) 113

71. Growth semi-tolerant to tolerant (>20% of controls) at 30°C .. 72

71. Growth sensitive (<20% of controls) at 30°C 89

72. Colonies bright lemon yellow ....83. *Piloderma bicolor*

72. Colonies other colours 73

73. Superficial growth only (colonies easily peeled from agar surface), colonies cottony, greyish brown ....1. *Strobilomyces floccopus*

73. Submerged mycelia in addition to aerial mycelia, colonies other colours 74

74. Tyrosinase present 75

74. Tyrosinase absent 84

75. Degradation of gelatin 76

75. Negative for gelatin degradation 81

76. Degradation of amylose 77

76. Negative for amylose degradation 79

77. Growth sensitive (<20% of controls) to malachite green (2ug/mL) ....48. *Amanita citrina*

77. Growth semi-tolerant to tolerant (>20% of controls) to malachite green (2ug/mL) 78

78. Growth sensitive (<20% of controls) to sodium chloride (10mg/mL), colonies possessing slow growth rate (<15 mm after 5 weeks) ....47. *Amanita brunnescens*

78. Growth semi-tolerant to tolerant (>20% of controls) to sodium chloride (10mg/mL), colonies possessing faster growth rate (>15 mm after 5 weeks) ....49. *Amanita flavoconia*

79. Growth tolerant (>50% of controls) to cycloheximide (2ug/mL) ....80. *Thelephora terrestris*

79. Growth sensitive (<20% of controls) to cycloheximide (2ug/mL) 80

80. Degradation of lipid, laccase absent ...50. *Amanita muscaria*

80. Negative for lipid degradation, laccase present ....71. *Lactarius indigo*

81. Negative for urea degradation (with growth) .50. *Amanita muscaria*

81. Positive for urea degradation (without growth) 82

82. Growth sensitive (<20% of controls) to sodium chloride (10mg/mL), associated with aspen (*Populus tremuloides* and *P.grandidentata*) ....26. *Leccinum aurantiacum*

82. Growth semi-tolerant to tolerant (>20% of controls) to sodium chloride (10mg/mL), associated with other hosts .. 83

83. Colonies pigmented and slow growing (<15 mm in 5 weeks), associated with *Betula* ....27. *Leccinum holopus*

83. Colonies white and faster growing (10-40 mm in 5 weeks), associated with *Hudsonia* ....25. *Leccinum arenicola*

84. Degradation of amylose 85

84. Negative for amylose degradation 86

85. Laccase absent ....49. *Amanita flavoconia*

85. Laccase present ....44. *Tricholoma resplendens*

86. Degradation of gelatin ....68. *Lactarius chelidonius*

86. Negative for gelatin degradation 87

87. Acidification of casamino acids agar after 12 weeks ....41. *Tricholoma myomyces*

87. Negative for acidification of casamino acids agar after 12 weeks 88

88. Colonies white ....42. *Tricholoma pessundatum*

88. Colonies brown ....82. *Coltricia perennis*

89. Colonies bright lemon yellow ....83. *Piloderma bicolor*

89. Colonies other colours 90

90. Superficial growth only (colonies easily peeled from agar surface), colonies cottony, greyish brown ....1. *Strobilomyces floccopus*

90. Submerged mycelia in addition to aerial mycelia, colonies other colours 91

91. Degradation of gelatin 92

91. Negative for gelatin degradation 98

92. Laccase absent 93

92. Laccase present 94

93. Tyrosinase present, wide host range ....50. *Amanita muscaria*

93. Tyrosinase absent, associated with Fagaceae (*Quercus* and *Fagus*) ....24. *Boletus ornatipes*

94. Negative for acidification of BCP-casamino acids agar after 12 weeks, growth tolerant (>50% of controls) to malachite green (2ug/mL) ....44. *Tricholoma resplendens*
94. Acidification of BCP-casamino acids agar after 12 weeks; growth sensitive (<20% of controls) to malachite green (2ug/mL), rarely semi-tolerant (20-50% of controls) 95
95. Tyrosinase present 96
95. Tyrosinase absent 97
96. Colonies with shades of green (on MN and Hagem's agar), wide host range among conifers ....69. *Lactarius deliciosus*
96. Colonies never with shades of green (on MN and Hagem's agar), associated with *Abies balsamea* in *Thuja* bogs, swamps and forests ....77. *Lactarius thyinos*
97. Associated with *Tsuga canadensis*, eastern North America ....75. *Lactarius subpurpureus*
97. Also associated with other conifers, throughout North America ....69. *Lactarius deliciosus*
98. Tyrosinase present 99
98. Tyrosinase absent 102
99. Brown pigments diffusing into agar (BAF and PDA), negative for lipid degradation ....94. *Zelleromyces gilkeyae*
99. Colonies not diffusing brown pigments into agar (BAF and PDA), positive for lipid degradation 100
100. Growth semi-tolerant to tolerant (>20% of controls) to cycloheximide (2ug/mL), pale violet colonies when young, and with conspicuous terminal swellings on hyphae ....59. *Cortinarius anomalus*
100. Growth sensitive (<20% of controls) to cycloheximide (2ug/mL), colonies white, without conspicuous terminal swellings on hyphae 101
101. Degradation of urea (without growth), restriction to aspen (*Populus tremuloides* and *P. grandidentata*) ....26. *Leccinum aurantiacum*
101. Negative for urea degradation (with growth), wide host range ....50. *Amanita muscaria*
102. Growth sensitive (<20% of controls) to malachite green (2ug/mL) 103
102. Growth semi-tolerant to tolerant (>20% of controls) to malachite green (2ug/mL) 104
103. Brown pigments diffusing into agar (BAF and PDA); colonies felty to appressed woolly, lacunose ....94. *Zelleromyces gilkeyae*
103. Colonies not diffusing brown pigments into agar (BAF and PDA); colonies cottony, not lacunose ....23. *Boletus edulis*
104. Acidification of BCP-casamino acids agar after 12 weeks ....41. *Tricholoma myomyces*
104. Negative for acidification of casamino acids agar after 12 weeks 105
105. Growth semi-tolerant to tolerant (>20% of controls) to sodium chloride (10mg/mL) 106
105. Growth sensitive (<20% of controls) to sodium chloride (10mg/mL) 107
106. Growth semi-tolerant to tolerant (>20% of controls) to cycloheximide (2ug/mL), associated with conifers ....36. *Tricholoma aurantium*

106. Growth sensitive (<20% of controls) to cycloheximide (2ug/mL), associated with *Salix* ...37. *Tricholoma cingulatum*
107. Colonies restricted in growth (<10mm in 5 weeks) ....65. *Russula subfoetens*
107. Colonies having faster growth rate (>15mm in 5 weeks) 108
108. Associated with broad-leaved hosts 109
108. Associated with coniferous hosts 110
109. Degradation of amylose, colonies brown, associated with *Betula* ....39. *Tricholoma fulvum*
109. Negative for amylose degradation, colonies white or whitish, associated with *Populus* ....43. *Tricholoma populinum*
110. Growth semi-tolerant to tolerant (>20% of controls) to cycloheximide (2ug/mL) 111
110. Growth sensitive (<20% of controls) to cycloheximide (2ug/mL) 112
111. Colonies pure white ....45. *Tricholoma vaccinum*
111. Colonies tinged with brown and grey ....40. *Tricholoma imbricatum*
112. Degradation of lipid, slight brown pigment diffusing into agar (BAF & PDA) ....38. *Tricholoma focale*
112. Negative for lipid degradation, no pigments diffusing into agar (BAF & PDA) ....35. *Tricholoma albobrunneum*
113. Growth semi-tolerant to tolerant (>20% of controls) to malachite green (2ug/mL) 114
113. Growth sensitive (<20% of controls) to malachite green (2ug/mL) 135
114. Tyrosinase present 115
114. Tyrosinase absent 117
115. Laccase present ....69. *Lactarius deliciosus*
115. Laccase absent 116
116. Growth semi-tolerant to tolerant (>20% of controls) at 30°C ....49. *Amanita flavoconia*
116. Growth sensitive (<20% of controls) at 30°C ....51. *Amanita rubescens*
117. Growth semi-tolerant to tolerant (>20% of controls) at 30°C.. 118
117. Growth sensitive (<20% of controls) at 30°C 123
118. Laccase absent 119
118. Laccase present 120
119. Degradation of lipid and amylose; negative for degradation of casamino acids ....49. *Amanita flavoconia*
119. Negative for degradation of lipid and amylose; positive for degradation of casamino acids ....42. *Tricholoma pessundatum*
120. Degradation of lipid, amylose and gelatin 121
120. Negative for lipid, amylose and gelatin degradation 122
121. Acidification of BCP-casamino acids agar after 12 weeks; positive (weak) for pectin degradation ....60. *Cortinarius brunneus*
121. Negative for acidification of BCP-casamino acids agar after 12 weeks; negative for pectin degradation..44.*Tricholoma resplendens*
122. Acidification of BCP-casamino acids agar after 12 weeks ....41. *Tricholoma myomyces*
122. Negative for acidification of BCP-casamino acids agar after 12 weeks ....42. *Tricholoma pessundatum*
123. Acidification of BCP-casamino acids agar after 12 weeks 124
123. Negative for acidification of BCP-casamino acids agar after 12 weeks 125

124. Degradation of gelatin ....69. *Lactarius deliciosus*

124. Negative for gelatin degradation ....41. *Tricholoma myomyces*

125. Growth semi-tolerant to tolerant (>20% of controls) to sodium chloride (10mg/mL) 126

125. Growth sensitive (<20% of controls) to sodium chloride (10mg/mL) 127

126. Growth semi-tolerant to tolerant (>20% of controls) to cycloheximide (2ug/mL); associated with conifers ....36. *Tricholoma aurantium*

126. Growth sensitive (<20% of controls) to cycloheximide (2ug/mL); associated with *Salix* ...37. *Tricholoma cingulatum*

127. Associated with broad-leaved hosts 128

127. Associated with coniferous hosts 129

128. Degradation of amylose, colonies brown, associated with *Betula* ....39. *Tricholoma fulvum*

128. Negative for amylose degradation, colonies white or whitish, associated with *Populus* ....43. *Tricholoma populinum*

129. Laccase present 130

129. Laccase absent 132

130. Growth sensitive (<20% of controls) to cycloheximide (2ug/mL) ....46. *Tricholoma virgatum*

130. Growth semi-tolerant to tolerant (>20% of controls) to cycloheximide (2ug/mL) 131

131. Growth rate 14-25 mm in 5 weeks, clamp connections never found ....36. *Tricholoma aurantium*

131. Growth rate 18-57mm in 5 weeks, clamp connections occasionally found ....45. *Tricholoma vaccinum*

132. Growth semi-tolerant to tolerant (>20% of controls) to cycloheximide (2ug/mL) 133

132. Growth sensitive (<20% of controls) to cycloheximide (2ug/mL) 134

133. Colonies white ....45. *Tricholoma vaccinum*

133. Colonies tinged with brown and grey ....40. *Tricholoma imbricatum*

134. Degradation of lipid, slight brown pigment diffusing into agar (BAF and PDA) ....38. *Tricholoma focale*

134. Negative for lipid degradation, no pigments diffusing into agar (BAF and PDA) ....35. *Tricholoma albobrunneum*

135. Laccase absent 136

135. Laccase present 139

136. Degradation of lipid ....50. *Amanita muscaria*

136. Negative for lipid degradation 137

137. Growth sensitive (<20% of controls) at 30°C ....66. *Russula velenovskyi*

137. Growth semi-tolerant to tolerant (>20% of controls) at 30°C.. 138

138. Acidification of BCP-casamino acids agar after 12 weeks ....79. *Lactarius vinaceorufescens*

138. Negative for acidification of BCP-casamino acids agar after 12 weeks ....81. *Bankera fuligineo-alba*

139. Degradation of gelatin 140

139. Negative for gelatin degradation 147

140. Associated with *Betula* 141

140. Associated with coniferous hosts 142

141. Degradation of amylose, negative for lipid degradation ....78. *Lactarius torminosus*

141. Negative for amylose degradation, positive for degradation of lipid ....73. *Lactarius pubescens*

142. Growth semi-tolerant to tolerant (>20% of controls) at 30°C 143

142. Growth sensitive (<20% of controls) at 30°C 144

143. Degradation of lipid, absense of tyrosinase ....68. *Lactarius chelidonius*

143. Negative for lipid degradation, tyrosinase present ....71. *Lactarius indigo*

144. Tyrosinase present 145

144. Tyrosinase absent 146

145. Colonies on MN and Hagem's agar tinged with green, associated with a wide range of coniferous hosts ...69. *Lactarius deliciosus*

145. Colonies on MN and Hagem's agar never tinged with green, associated with *Abies balsamea* in *Thuja* bogs, swamps and forests ....77. *Lactarius thyinos*

146. Associated with *Tsuga canadensis* ..75. *Lactarius subpurpureus*

146. Associated with other coniferous hosts in addition to *Tsuga* ....69. *Lactarius deliciosus*

147. Growth semi-tolerant to tolerant (>20% of controls) at 30°C ....79. *Lactarius vinaceorufescens*

147. Growth sensitive (<20% of controls) at 30°C 148

148. Growth semi-tolerant to tolerant (>20% of controls) to sodium chloride (10mg/mL) 149

148. Growth sensitive (<20% of controls) to sodium chloride (10mg/mL) 151

149. Degradation of amylose ....74. *Lactarius rufus*

149. Negative for amylose degradation 150

150. Tyrosinase absent ....67. *Lactarius affinis*
72. *Lactarius mucidus*

150. Tyrosinase present ....67. *Lactarius affinis*
74. *Lactarius rufus*

151. Colonies greyish orange after 5 weeks, non-treated mycelia failing to stain with diazonium blue B, pigment diffusing into agar of older colonies ....70. *Lactarius hibbardae*

151. Colonies orange brown after 5 weeks, non-treated mycelia staining yellow with diazonium blue B, pigment not diffusing into agar 152

152. Negative for urea degradation (±growth) ....76. *Lactarius thejogalus*

152. Degradation of urea (no growth) 153

153. Tyrosinase present ....67. *Lactarius affinis*

153. Tyrosinase absent ....67. *Lactarius affinis*
72. *Lactarius mucidus*

SYNOPTIC KEY TO THE *IN VITRO* IDENTIFICATION OF ECTOMYCORRHIZAL FUNGI

A. ENZYMATIC DEGRADATION

1. Pectin degradation
60

2. Lipid degradation
4 24 25 26 27 38 44 47 48 49 50 59 60 61 64 68 69 73 77 80 96

3. Lack of lipid degradation
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 27 28 29 30 31 32 33 34 35 36 37 39 40 41 42 43 45 46 52 53 54 55 56 57 58 61 62 63 65 66 67 69 70 71 72 74 75 76 77 78 79 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96
4. Amylose degradation
8 9 22 24 27 39 44 46 47 48 49 51 52 53 57 58 59 60 63 69 70 74 75 76 77 78 81 96
5. Lack of amylose degradation
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 40 41 42 43 45 46 50 53 54 55 56 59 61 62 64 65 66 67 68 69 70 71 72 73 74 76 77 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95
6. Gelatin degradation
22 24 32 35 44 47 48 49 50 51 53 54 57 58 60 62 64 68 69 71 73 75 77 78 80 81 83
7. Lack of gelatin degradation
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 23 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 45 46 50 51 52 53 54 55 56 59 61 63 65 66 67 70 72 74 76 79 81 82 84 85 86 87 88 89 90 91 92 93 94 95 96
8. Degradation of casamino acids
20 24 31 32 34 35 36 37 42 45 46 52 53 54 82 83 92 95 96
9. Lack of casamino acids degradation
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 21 22 23 24 25 26 27 28 29 30 32 33 36 38 39 40 41 43 44 45 46 47 48 49 50 51 52 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 84 85 86 87 88 89 90 91 92 93 94 96
10. Acidification of BCP-casamino acids agar
18 29 30 41 47 48 49 50 52 54 55 59 60 61 62 63 64 66 67 68 69 70 71 72 74 75 76 77 78 79 83
11. Lack of acidification of BCP-casamino acids agar
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 19 20 21 22 23 24 25 26 27 28 31 32 33 34 35 36 37 38 39 40 42 43 44 45 46 50 51 52 53 56 57 58 61 65 66 73 80 81 82 84 85 86 87 88 89 90 91 92 93 94 95 96
12. Urea degradation (with growth)
31 32 33 34 37 41 42 43 52 53 54 55 56 80 96
13. Urea degradation (without growth)
1 6 9 10 12 16 19 20 21 22 23 24 25 26 27 37 39 44 46 56 59 60 61 64 67 68 69 70 71 72 73 74 77 79 84 85 86 87 92 96
14. Lack of urea degradation (with growth)
2 3 4 5 7 8 9 10 11 13 15 17 18 28 29 30 35 36 38 39 40 41 42 43 45 46 47 48 49 50 51 64 66 69 74 76 79 81 82 88 89 90 91 96
15. Lack of urea degradation (without growth)
2 6 9 10 12 14 18 21 27 28 40 47 57 58 62 63 65 71 74 75 76 77 78 81 83 88 89 92 93 94 95

B. TEMPERATURE

16. Growth ≥20% of controls at 7°C
5 12 17 27 28 31 32 34 37 41 52 53 54 55 56 63 83 94
17. Growth <20% of controls at 7°C
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 33 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96
18. Growth ≥20% of controls at 30°C
1 2 4 5 6 8 9 10 11 12 14 15 16 17 18 25 26 27 28 31 32 33 34 41 42 44
47 48 49 50 52 53 54 56 60 62 68 71 73 79 80 81 82 83 84 85 86 87 88
89 91 95 96
19. Growth <20% of controls at 30°C
1 3 7 9 13 18 19 20 21 22 23 24 26 28 29 30 35 36 37 38 39 40 41 43 45
46 50 51 52 54 55 57 58 59 61 63 64 65 66 67 69 70 72 73 74 75 76 77
78 83 90 92 93 94 96

C. FUNGITOXICANTS
20. Growth tolerant (≥50% of controls) to benomyl (10ug/mL)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
27 28 29 30 31 32 33 34 35 37 41 44 47 57 58 59 61 63 64 65 68 69 71
75 77 80 83 84 85 86 87 88 89 90 91 92 93 94 95
21. Growth semi-tolerant to tolerant (≥20% of controls) to benomyl
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 47 48 49 50
57 58 59 61 62 63 64 65 68 69 71 75 77 80 82 83 84 85 86 87 88 89 90
91 92 93 94 95
22. Growth sensitive (<20% of controls) to benomyl
36 38 39 42 45 46 48 49 50 51 52 53 54 55 56 60 62 66 67 68 69 70 71
72 73 74 75 76 77 78 79 81 96
23. Growth tolerant (≥50% of controls) to cycloheximide (2ug/mL)
6 17 22 28 30 31 32 33 34 41 48 49 52 53 54 55 56 67 79 80 83 84 87 88
89 91 92 94 96
24. Growth semi-tolerant to tolerant (≥20% of controls) to cycloheximide
3 4 5 6 9 10 11 12 14 15 16 17 20 21 22 24 28 30 31 32 33 34 36 39 40
41 42 45 47 48 49 51 52 53 54 55 56 59 60 61 67 76 79 80 81 83 84 87
88 89 91 92 94 96
25. Growth sensitive (<20% of controls) to cycloheximide
2 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 23 24 25 26 27 29 35 37 38
42 43 44 46 50 55 57 58 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76
77 78 79 82 83 85 86 90 92 93 95
26. Growth tolerant (≥50% of controls) to rose bengal (10ug/mL)
2 3 5 6 8 9 10 11 12 13 14 15 16 17 18 20 21 24 26 28 31 32 33 34 36
37 39 40 41 42 44 45 46 47 48 49 50 51 52 53 56 57 58 59 60 61 63 65
67 68 69 71 75 77 78 79 80 83 84 86 88 89 92 96
27. Growth semi-tolerant to tolerant (≥20% of controls) to rose bengal
2 3 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 24 26 28 31 32 33 34
35 36 37 38 39 40 41 42 44 45 46 47 48 49 50 51 52 53 56 57 58 59 60
61 62 63 65 67 68 69 70 71 73 74 75 77 78 79 80 83 84 86 88 89 90 91
92 94 96
28. Growth sensitive (<20% of controls) to rose bengal
4 6 7 9 17 19 21 22 23 24 25 27 28 29 30 35 38 41 42 43 45 50 54 55 62
64 66 67 70 72 73 74 76 77 78 79 81 82 83 85 87 90 91 92 93 95
29. Growth tolerant (≥50% of controls) to malachite green (2ug/mL)
3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 24 28 30 31 35 36 37 38
39 40 41 42 43 44 45 46 47 49 51 52 53 54 55 56 57 58 60 63 65 83 84
85 86 87 88 89 90 91 92 93 96
30. Growth semi-tolerant to tolerant (≥20% of controls) to malachite green
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 24 25 26 28 30 31
32 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55

56 57 58 60 63 64 65 69 80 82 83 84 85 86 87 88 89 90 91 92 93 96
31. Growth sensitive (<20% of controls) to malachite green
5 6 8 19 20 22 23 27 29 31 32 33 45 48 50 59 61 62 66 67 68 69 70 71 72 73 74 75 76 77 78 79 81 82 93 94 95
32. Growth tolerant ($\geq$50% of controls) to sodium chloride (10mg/mL)
5 6 7 8 9 10 12 13 14 15 16 17 18 19 27 28 31 32 33 34 37 48 50 52 53 54 56 57 63 67 72 74 79 83 84 87
33. Growth semi-tolerant to tolerant ($\geq$20% of controls) to sodium chloride
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 25 27 28 31 32 33 34 36 37 41 48 49 50 51 52 53 54 56 57 58 59 61 63 66 67 69 72 74 79 81 83 84 86 87 91 95 96
34. Growth sensitive (<20% of controls) to sodium chloride
4 11 20 21 22 23 24 26 29 30 35 36 38 39 40 41 42 43 44 45 46 47 50 55 60 62 64 65 66 67 68 69 70 71 73 75 76 77 78 79 80 82 83 85 88 89 90 91 92 93 94 96

D. POLYPHENOL OXIDASE PRODUCTION

35. Laccase produced on most media
30 31 36 37 39 41 44 46 52 54 56 59 60 61 67 68 69 70 71 72 73 74 75 76 77 78 79 80 92 94
36. Laccase absent on all media
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 27 28 31 32 33 34 35 38 40 42 43 45 47 48 49 50 51 53 55 57 58 61 62 63 64 65 66 81 82 83 84 85 86 87 88 89 90 91 93 95
37. Tyrosinase produced on most media
6 17 18 19 20 25 26 27 31 32 33 34 47 48 49 50 51 52 54 55 58 59 62 63 66 67 69 70 71 73 74 76 77 78 79 80 84 85 86 88 89 91 92 93 95
38. Tyrosinase absent on all media
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 21 22 23 24 28 29 30 35 36 37 38 39 40 41 42 43 44 45 46 49 53 56 57 60 61 64 65 67 68 69 72 75 79 81 82 83 87 90
39. Laccase dominant
30 36 37 39 41 42 44 45 46 56 60 61 67 68 69 72 74 75 79 94
40. Tyrosinase dominant
6 17 18 19 20 25 26 27 31 32 33 34 47 48 49 50 51 53 55 58 62 63 66 80 84 85 86 88 89 91 93 95
41. Equivalent for laccase and tyrosinase
26 29 31 52 54 55 59 67 69 70 71 73 74 76 77 78 79 80 92 94
42. Negative for laccase and tyrosinase
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 21 22 23 24 28 35 38 40 42 43 45 49 53 57 61 64 65 81 82 83 87 90

E. DIAZONIUM BLUE B STAINING REACTION

43. Non KOH pre-treated mycelia staining red
10 12 14 21 22 23 24 49 71
44. Non KOH pre-treated mycelia staining yellow
4 5 8 17 29 30 31 32 33 34 35 36 37 38 39 40 42 43 45 46 47 51 52 53 54 55 56 65 66 67 68 72 74 76 79 83 85 93 95
45. Non KOH pre-treated mycelia failing to stain
1 2 4 6 7 9 11 15 16 18 19 20 24 25 26 27 28 41 44 48 50 57 58 59 60 61 62 63 69 70 73 75 77 78 80 81 86 87 88 89 90 91 92 93

F. MORPHOLOGICAL CHARACTERS

46. Clamp connections present at most or every septum
3 4 28 29 30 31 32 33 34 50 52 53 54 55 56 57 58 60 61 62 63 64 80 84 85 86 87 92 95

47. Clamp connections absent from most or every septum
1 2 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 59 60 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 88 89 90 91 93 94 96

48. Clamp connections astatocoenocytic
50

49. Colonies appressed
22 29 30 31 32 33 34 51 62 64 66 67 68 70 71 72 76 77 78 79 80 81 93 95 96

50. Colonies cottony to cottony-felty
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 23 24 25 26 27 28 35 36 37 38 39 40 41 42 43 45 46 47 48 49 50 51 52 54 55 56 57 58 59 60 61 63 82 83 84 85 86 87 88 89 90 91 92 93

51. Colonies velvety to felty
8 12 13 15 16 17 18 22 27 28 30 39 40 41 43 44 50 51 52 59 60 61 63 83 88 89 90 91 92 93 94 96

52. Colonies flocculose to floccose
15 27 28 31 32 33 34 41 46 52 53 60 65 67 68 69 71 72 73 74 75 76 77 78 80 95

53. Colonies funiculose
31 60 64 68 69 71 73 75 77 78

54. Colonies ±lacunose
3 5 6 8 9 10 12 13 14 15 16 17 18 22 24 25 26 28 29 30 31 32 35 36 37 39 40 42 43 44 45 48 49 50 51 52 53 54 56 57 58 59 61 62 63 64 71 78 80 81 83 88 89 90 91 92 93 94

55. Colonies hyaline
33 34 62 66 79 80

56. Colonies white
3 4 6 7 9 11 12 14 16 17 18 19 20 21 23 25 26 32 34 35 36 37 38 41 42 43 44 45 46 47 48 49 50 51 52 53 54 56 57 58 59 60 61 65 66 84 85 86 88 89 91 95

57. Colonies whitish to shades of yellowish brown
2 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 24 27 28 30 36 38 39 40 41 43 45 47 51 60 61 62 64 65 81 84 85 86 88 89 90 91 92 94 95

58. Colonies deep lemon yellow
83

59. Colonies light orange to reddish brown
29 30 56 67 68 69 70 71 72 73 74 75 76 77 78 79 80

60. Colonies tinged with green
41 69 71 75

61. Colonies bluish to violet or with tinges of these colours
31 33 57 58 59 61 63

62. Colonies brownish or with tinges of brown
1 4 5 6 8 10 11 12 13 14 17 18 22 27 28 36 38 39 40 55 80 82 87 92 93 94 95

63. Colonies greyish brown or with tinges of greyish brown
1 8 10 27 92 94

64. Colonies black
96

65. Growth rate ≥70 mm in 5 weeks
3 7 9 16 18 21 28 31 32 34 35 53 80 88 91 92
66. Growth rate 50-70 mm in 5 weeks
3 4 5 6 7 9 11 13 15 16 17 18 20 21 23 28 31 32 34 35 38 42 43 45 50
52 53 80 88 89 91 92
67. Growth rate 25-50 mm in 5 weeks
2 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 28 29
30 31 32 37 38 39 40 41 43 45 48 49 50 51 52 54 55 56 57 58 60 61 67
68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 84 85 86 87 88 89 90 91
92 93 94 95 96
68. Growth rate 10-25 mm in 5 weeks
1 12 21 22 24 25 26 27 28 30 33 36 39 40 41 44 45 46 47 48 49 50 51 52
55 56 57 58 59 60 61 62 63 64 66 67 68 69 70 72 73 74 75 76 77 78 79
80 81 83 84 85 86 87 92 93 95 96
69. Growth rate <10 mm in 5 weeks
1 22 25 27 30 46 47 50 51 59 62 63 64 65 66 73 77 78 79
70. Colony outline ± circular
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 23 24 25 26 27 28
29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 48 49 50 51 52
53 54 55 56 60 61 63 64 65 66 67 68 70 71 72 73 74 75 76 79 81 82 83
84 85 86 87 88 89 90 91 92 93 94 95 96
71. Colony outline polygonal
3 9 15 18 55 83 88 92
72. Colony outline ± ellipsoidal
29 30 46 61 62 64 65 70 87 96
73. Colony outline irregularly circular
1 4 5 6 7 8 9 10 12 13 16 17 19 20 21 22 23 24 25 26 27 28 30 35 36 39
40 43 46 47 48 50 51 52 54 57 58 59 61 63 67 68 69 71 72 73 75 77 78
79 81 93
74. Colony outline irregular
22 24 27 50 58 59 63 68 69 71 75 77 78 80
75. Pigmentation of agar (BAF and PDA) with brown pigments in 5 weeks
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 24 27 28 38 39
82 84 85 86 87 88 89 90 91 92 93 94
76. Pigmentation of agar (BAF and PDA) with yellow pigments in 5 weeks
60
77. Brown pigments not exuding into agar (BAF and PDA) in 5 weeks
23 24 25 26 27 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46
47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69
70 71 72 73 74 75 76 77 78 79 80 81 82 83 95 96
78. hyphal threads frequently produced
4 20

G. HOST ASSOCIATIONS
79. Angiosperm as host
1 2 20 21 24 25 26 27 28 30 31 32 33 34 37 39 43 44 47 50 51 52 55 56
58 59 63 64 65 66 71 73 78 84 85 86 87 92 95 96
80. Gymnosperm as host
3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 28 29 31 32 34
35 36 38 40 41 42 45 46 48 49 50 52 53 54 55 57 58 59 60 61 62 63 64
65 67 68 69 70 71 72 74 75 76 77 79 80 81 82 83 84 85 86 87 88 89 90
91 93 94 96

DESCRIPTION OF CULTURES

AGARICALES

STROBILOMYCETACEAE

1. Strobilomyces floccopus (Vahl: Fr.) Karst.
MACROMORPHOLOGY: BAF: irregularly circular, 6-13 mm in diameter, cottony, very superficial, light brown (7D4) at centre and brownish grey (7D2) elsewhere, with a raised even margin. Reverse black, white to yellowish white (4A2) at the margin. PDA: irregularly circular, 8-15 mm in diameter, cottony, very superficial, dark grey (F1), becoming brown (6E5) at centre surrounded by light grey (D1) to dark grey (F1), with a raised even margin. Reverse black, white to yellowish white (4A2) at the margin. MN: slightly irregularly circular, 6.5 mm in diameter, cottony, very superficial, dark brown (6F4), with a raised even margin. Reverse black, white at the margin. Hagem's: irregularly circular, (6-)10-17 mm in diameter, cottony, greyish brown (6E3) surrounded by medium grey (E1), white at the raised even margin. Reverse black, white at the margin.
MICROMORPHOLOGY: Hyphae (2.6-)3.2-5.2(-6.5) um in diameter, slightly pigmented, lacking clamp connections, frequently with globose to subglobose swellings.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), casamino acids degradation (-), acidification of BCP-casamino acids agar (-), urease (+, growth absent), polyphenol oxidase activity (negative), DBB reaction on non-treated mycelium (negative).
HABITAT: in deciduous and mixed woods, eastern North America (Smith and Thiers 1971; Miller 1980; Lincoff 1981; McKnight and McKnight 1987).
ISOLATE EXAMINED: USA: MASSACHUSETTS: Franklin Co., Mt. Toby Forest Reserve, 8 km N of Amherst, under Quercus rubra and Tsuga canadensis, 12.viii.86, R.G.Thorn LH-17-86 (isolate lost).
LITERATURE REPORTS OF CULTURAL CHARACTERS: Besl et al. (1989).
REMARKS: This species was difficult to grow and maintain because it produces only superficial mycelium, rendering viable transfers difficult to make. The dark greyish-brown colonies which were irregular in outline, the superficial growth and the lightly pigmented hyphae were the distinctive features for this species.

2. Boletellus russellii (Frost) Gilbert
MACROMORPHOLOGY: BAF: circular, 24-25 mm in diameter, cottony to felty, pale yellow (3A3) with an appressed even margin. Reverse violet brown (10F8) to black. Opaque brown pigment forming a halo around the colony. PDA: circular, 30-31 mm in diameter, cottony to felty, producing honey-coloured droplets on surface in centre, yellowish orange (4A6), whitish at appressed even margin. Reverse violet brown (10F8), brownish red (8C8) at the margin. Dark brown pigment diffusing into the agar. MN: circular, 31-32 mm in diameter, cottony in tufts to felty, producing honey-coloured droplets on surface in centre, pale yellow (3A3), reddish brown (9E5) at the appressed to slightly raised even margin. Reverse violet brown (10F8) surrounded by reddish brown (8E8) at the margin. Dark brown pigment diffusing into the agar. Hagem's: circular, 25-33 mm in diameter, cottony in tufts, producing honey-coloured droplets on surface, pale yellow (3A3) with an appressed even greyish brown (8D3)

margin. Reverse violet brown (10F8) surrounded by brownish red (8C8) at the margin. Opaque pigment diffusing into the agar.
MICROMORPHOLOGY: Hyphae (1.6-)2.0-3.2(-4.5) um in diameter, hyaline, lacking clamp connections, producing only a few slight swellings.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), casamino acids degradation (-), acidification of BCP casamino acids agar (-), urease activity (-, growth present/absent), sensitive at 7°C, tolerant at 30°C, tolerant to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), semi-tolerant to malachite green (2ug/mL), semi-tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (negative), DBB reaction on non-treated mycelia (negative).
HABITAT: in open deciduous or mixed woods under *Quercus*, eastern North America (Snell and Dick 1970; Smith and Thiers 1971; Lincoff 1981; McKnight and McKnight 1987).
ISOLATE EXAMINED: CANADA: ONTARIO: Lambton Co., Pinery Provincial Park, under *Quercus velutina* and *Pinus resinosa*, 22.viii.83, R.G.Thorn UAMH 5938.

BOLETACEAE

Boletinus

Colonies white and cottony with dark brown pigments diffusing into the agar (BAF and PDA); hyphae possessing clamp connections; always associated with *Larix*; amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-), urease (-, growth present); tolerant to benomyl and malachite green; polyphenol oxidase activity (negative).

3. *Boletinus cavipes* (Opat.) Kalchbr.
MACROMORPHOLOGY: BAF: polygonal, 52-63 mm in diameter, cottony to felty, radially lacunose, mycelium reaching lid of petri dish, white to beige (4C3) with a raised even margin. Reverse violet brown (10F8) in centre surrounded by violet brown (10E8) with brownish orange (7C8) at the margin, radial grooves visible beneath colony. Brown pigment diffusing into the agar. PDA: circular, 56-77 mm in diameter, cottony, white with a raised even margin. Reverse violet brown (10F8) surrounded by brownish red (8C8) with orange at the margin (6B8). Brown pigment diffusing into the agar. MN: circular, usually covering plate in 5 weeks, cottony, mycelium reaching lid of petri dish, white with a raised even margin. Reverse dark brown (7F8) in centre surrounded by a band of brown (6E5) then another band of reddish brown (9E8) to brownish orange (6C6) with pale yellow (4A3) at the margin. Hagem's: circular, usually covering plate in 5 weeks, cottony, mycelium reaching lid of petri dish, white with a raised even margin. Reverse violet brown (10E8) in centre surrounded by greyish orange (5B5) with light yellow (4A4) at the margin.
MICROMORPHOLOGY: Hyphae (1.9-)2.6-5.2(-7.1) rarely up to 7.8 um in diameter, hyaline, possessing clamp connections.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), casamino acids degradation (-), acidification of BCP-casamino acids agar (-), urease activity (-, growth present), sensitive at 7°C, sensitive at 30°C, tolerant to benomyl (10ug/mL), semi-tolerant to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), tolerant

to malachite green (2ug/mL), semi-tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (negative).
HABITAT: in coniferous woods under *Larix* throughout range of *Larix* in North America (Snell and Dick 1970; Smith and Thiers 1971; Miller 1980; Lincoff 1981; McKnight and McKnight 1987).
ISOLATE EXAMINED: CANADA: QUEBEC: Nouveau Québec Territory, 10 km NW of Schefferville at Star Creek, under *Larix laricina* and *Picea glauca*, 25.viii.84, D.W.Malloch UAMH 6144.
LITERATURE REPORTS OF CULTURAL CHARACTERS: Pantidou (1961), Laut (1966), Besl *et al*. (1989).

4. *Boletinus paluster* (Peck) Peck
MACROMORPHOLOGY: BAF: circular to irregularly circular, (24-)31-37(-48) mm in diameter, cottony, sometimes felty in centre, lacunose, mycelium reaching lid of petri dish, sometimes reddish brown (9E8) in centre, white elsewhere, with a raised even to uneven margin. Reverse dark brown (9F8) to violet brown (10F8) in centre surrounded by brownish red (8C8) to reddish brown (9E8), sometimes with light orange (6A5) at the margin, radial grooves sometimes visible from beneath the colony. Intense reddish brown pigment diffusing into the agar. PDA: circular to slightly irregularly circular, 28-39 mm in diameter, cottony to felty, sometimes slightly flocculose towards margin, mycelium reaching lid of petri dish, pale yellow (4A3) to brown (7E8) in centre, white elsewhere, with a raised even margin. Reverse violet brown (10F8-11F8) in centre, surrounded by violet brown (11E8), with reddish brown (8C7-8D8) at the margin. Brown to reddish brown pigment diffusing into the agar. MN: circular to irregularly circular, 39-56 mm in diameter, cottony becoming somewhat felty towards margin, sometimes lacunose, mycelium touching lid of petri dish, white, sometimes tinged with brown (7E8) towards centre, with a raised even margin. Reverse dark brown (7F8-8F8) in centre surrounded by greyish orange (5B6) to brown (7E8) with yellowish white (4A2) to light orange (5A5) at the margin, radial grooves visible below colony when lacunose. Light brown pigment sometimes diffusing into the agar. Hagem's: circular to slightly irregularly circular, 35-50 mm in diameter, cottony, mycelium touching lid of petri dish, yellowish brown (5E8) in centre, white elsewhere, with a raised uneven margin. Reverse reddish brown (8E8) in centre surrounded by greyish orange (5B5-6B6) with light yellow (4A4) at the margin, radial grooves often visible from below colony.
MICROMORPHOLOGY: Hyphae (1.3-)2.0-3.9(-4.5) um in diameter, hyaline, possessing clamp connections. Oleiferous hyphae sometimes present. A few hyphal threads produced.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-/+), amylase (-), gelatinase (-), casamino acids degradation (-), acidification of BCP-casamino acids agar (-), urease activity (-, growth present), sensitive at 7°C, semi-tolerant at 30°C, tolerant to benomyl (10ug/mL), sensitive to semi-tolerant to cycloheximide (2ug/mL), sensitive to rose bengal (10ug/mL), tolerant to malachite green (2ug/mL), sensitive to semi-tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (negative), DBB reaction on non-treated mycelia (negative/yellow).
HABITAT: in sphagnum bogs under *Larix laricina*, eastern Canada and adjacent northeastern United States (Snell and Dick 1970).
ISOLATES EXAMINED: CANADA: ONTARIO: Muskoka District, 42 km NW of Dorset, under *Larix laricina*, 19.ix.86, L.J.Hutchison UAMH 5925; QUEBEC:

Nouveau Québec Territory, Poste de la Baleine, under *Larix laricina*, 2.ix.83, J.Samson CRBF 375.
LITERATURE REPORTS OF CULTURAL CHARACTERS: Pantidou and Groves (1966).

Suillus

Colonies white and cottony with dark brown pigments diffusing into the agar (BAF and PDA); hyphae lacking clamp connections, or if present very rare; associated with members of the Pinaceae; lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-, except *S.umbonatus*); tolerant to benomyl, mostly tolerant to malachite green, mostly sensitive to cycloheximide; polyphenol oxidase activity (negative, rarely tyrosinase dominant).

5. *Suillus americanus* (Peck) Snell

MACROMORPHOLOGY: BAF: circular to slightly irregularly circular, 29-41 mm in diameter, cottony to floccose, lacunose, light yellow (4A4) to brown (6E8) in centre, white at the raised even to uneven margin where agar is sometimes depressed. Reverse brown (6E8) to dark brown (6F8-8F8) in centre surrounded by reddish brown (8E8) at the margin. Brown opaque pigment forming halo around colony. PDA: circular to slightly irregularly circular, 37-48(-55) mm in diameter, cottony to floccose, sometimes subfelty, often lacunose, producing brown droplets on surface, greyish yellow (4C4) to light brown (6D4) through to yellowish brown (5E8-5F4), whitish at appressed to raised ± even margin. Reverse dark brown (7F8) to violet brown (11F8) in centre surrounded by brownish red (10D8) to violet brown (10E8), with orange (6B7) to reddish orange (7A8) at the margin. Brown pigment diffusing into the agar. MN: circular to slightly irregularly circular, 38-56 mm in diameter, floccose to cottony, lacunose, brownish grey (6E2) to brown (7E5) in centre surrounded by yellowish white (4A2) to pale orange (5A3), with pale grey (B1) to white elsewhere, with a raised even margin. Reverse dark brown (6F8) in centre surrounded by light brown (6D6) with light yellow (4A5) to greyish orange (5B6) at the margin. Very light pigment often diffusing into agar. Hagem's: slightly irregularly circular to irregular, 35-43(-55) mm in diameter, felty to cottony, lacunose, sometimes sectoring, yellowish white (4A2) to greyish yellow (4B4) in centre, white at the raised uneven margin. Reverse zonate in appearance with reddish brown (8D6) in centre surrounded by greyish orange (5B6) to yellowish brown (5E8) then surrounded by a band of greyish orange (5B5) to reddish brown (8D4) with yellowish white (4A2) to greyish orange (5B5) at the margin.
MICROMORPHOLOGY: Hyphae (1.6-)2.0-4.2(-5.2) rarely up to 6.5 um in diameter, hyaline, lacking clamp connections, although rarely a few clamp connections may be encountered.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), casamino acids degradation (-), acidification of BCP casamino acids agar (-), urease activity (-, growth present), sensitive (rarely semi-tolerant) at 7°C, semi-tolerant at 30°C, tolerant to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), semi-tolerant to tolerant to rose bengal (10ug/mL), sensitive to semi-tolerant to malachite green (2ug/mL), semi-tolerant to sodium chloride (10 mg/mL), polyphenol oxidase activity (negative), DBB reaction on non-treated mycelia (yellow).

HABITAT: in coniferous and mixed woods under Pinus strobus in eastern North America (Snell and Dick 1970; Smith and Thiers 1970; Miller 1980; Lincoff 1981; McKnight and McKnight 1987).
ISOLATES EXAMINED: CANADA: ONTARIO: Dufferin Co., Dufferin Co. Forest, in mixed woods under Pinus strobus, 15.ix.85, R.C.Summerbell UAMH 5934; York Co., North York, York University campus, on lawn beneath Pinus strobus, 23.ix.86, W.Untereiner-McNeely UAMH 5800.
LITERATURE REPORTS OF CULTURAL CHARACTERS: Pantidou and Groves (1966).

6. Suillus brevipes (Peck) Kuntze
MACROMORPHOLOGY: BAF: circular to irregularly circular, (22-)27-43(-62) mm in diameter, cottony, lacunose, rarely producing honey-coloured droplets on surface, greyish yellow (4C4) to light brown (6D4-6D6) through to brown (6E8) in centre, white to pale yellow (3A3) at the raised even margin. Reverse dark brown (6F8-8F5) to violet brown (10F8) in centre surrounded by brownish orange (7C8) to violet brown (10E7), with orange (5B8-6B8) to pastel red (7A5) at the margin, radial grooves visible from beneath colony sometimes resulting in cracking of agar. Opaque brownish orange pigment forming halo around colony. PDA: circular to irregularly circular (rarely irregular), (19-)27-43(-55) mm in diameter, cottony to flocculose to felty, lacunose, producing black droplets on surface, rarely sectoring with sectors felty, yellowish grey (4B2) to yellowish brown (5D4-5D8) through to brown (7E8) in centre with a white to pale yellow (3A3) raised to appressed ± even margin. Reverse dark brown (7F5-9F8) in centre with orange (6B7) to orange red (8B8) at the margin, agar rarely cracking beneath the colony. Light to dark brown to orange brown pigment diffusing into agar. MN: circular to slightly irregularly circular, (22-)28-53(-72) mm in diameter, cottony to felty, often lacunose, mycelium sometimes touching lid of petri dish, sometimes producing honey-coloured droplets of liquid on surface, orange white (6A2) to brownish orange (6C3) through to brown (6E8) in centre, white to pale grey (B1) towards a raised ± even margin. Reverse dark brown (7F8-8F8) to violet brown (10F8-11F8) surrounded by light brown (7D4-7D8) to reddish brown (8E8-9D8), with orange (5A6-6B7) at the margin, radial grooves frequently visible beneath colony often resulting in cracking of the agar. Light brownish orange to reddish brown pigment diffusing into the agar. Hagem's: circular to slightly irregularly circular (rarely irregular), (22-)31-56(-73) mm in diameter, cottony, rarely felty, very rarely lacunose, mycelium sometimes reaching lid of petri dish, white, sometimes orange white (5A2) to brownish orange (6C5) in centre, with a raised even margin. Reverse light brown (7D8) to dark brown (6F8) through to violet brown (10E8-11F8) in centre surrounded by brownish orange (6C7-7C8) to brown (6E8), with yellowish white (4A2) to light orange (5A4) at the margin, radial grooves frequently visible beneath colony rarely resulting in cracking of agar. Brown pigment rarely diffusing into the agar.
MICROMORPHOLOGY: Hyphae (1.3-)2.0-3.9(-4.5) rarely up to 6.5 um in diameter, hyaline, lacking clamp connections, producing a few globose to ellipsoidal swellings when submerged and growing on MN agar. A few oleiferous hyphae present.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), casamino acids degradation (-), acidification of BCP-casamino acids agar (-), urease activity (+, with no growth; rarely -), sensitive at 7°C, tolerant at 30°C, tolerant to benomyl (10ug/mL),

mostly sensitive but sometimes semi-tolerant to tolerant to cycloheximide (2ug/mL), sensitive to tolerant to rose bengal (10ug/mL), sensitive to tolerant to malachite green (2ug/mL), tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (negative/tyrosinase dominant), DBB reaction on non-treated mycelia (negative).
HABITAT: in coniferous forests under 2- and 3- needle pines and rarely *Picea*, throughout North America (Snell and Dick 1970; Smith and Thiers 1971; Thiers 1975; Miller 1980; Lincoff 1981; McKnight and McKnight 1987).
ISOLATES EXAMINED: CANADA: ONTARIO: Timiskaming District, Burt Twp., Burt Lake, under *Pinus banksiana*, 29.viii.83, E.Schwärtzel UAMH 6159; under *Pinus banksiana* and *Picea glauca*, 24.viii.86, L.J.Hutchison UAMH 5923; Nipissing District, Algonquin Provincial Park, Canisbay Twp., under *Pinus resinosa* and *Pinus strobus*, 18.x.86, L.J.Hutchison UAMH 5801; ALBERTA: Edson Forest, under *Pinus contorta*, 5.ix.85, R.S.Currah UAMH 5184; Rocky-Clearwater Forest, under *Pinus contorta*, *Picea glauca*, and *Picea mariana*, 6.viii.86, R.S.Currah UAMH 5467.
LITERATURE REPORTS OF CULTURAL CHARACTERS: Pantidou and Groves (1966).
REMARKS: *S.brevipes* differs from most other pine-associated *Suillus* species by degrading urea but exhibiting no growth on urease test agar. Otherwise only *S.subluteus* possesses this character; cultures of both species however, are indistinguishable. *S.subluteus* is restricted to *P.banksiana* in eastern North America while *S.brevipes* is found associated with 2- and 3- needle pines throughout North America.

7. *Suillus glandulosus* (Peck) Singer

MACROMORPHOLOGY: BAF: ±circular to slightly irregularly circular, 38-72(-85) mm in diameter, cottony, producing clear to light brown droplets on surface, white with tinges of greyish beige (4C2), with a raised even margin. Reverse yellowish brown (5F8) in centre, surrounded by brownish orange (5C3) with orange white (5A2) at the margin, radial grooves visible beneath colony, radiating in a clockwise spiral. PDA: slightly irregularly circular, 42-70 mm in diameter, cottony, producing honey-coloured droplets on surface centre, yellowish brown (5E8) surrounded by brownish orange (5C3), with yellowish white at a raised even margin. Reverse yellowish brown (5F5) surrounded by brownish orange (5C4) with pastel yellow (3A4) at the margin. Yellowish brown pigment diffusing into the agar. MN: ±circular to slightly irregularly circular, 70-75 mm in diameter, cottony, mycelium touching lid of petri dish, white with a raised ±even to slightly uneven margin. Reverse dark brown (6F5) with greyish orange (5B3) at the margin. Hagem's: slightly irregularly circular to slightly polygonal, 54-67 mm in diameter, cottony, mycelium touching lid of petri dish, white to yellowish grey (4B2), with a raised ±even margin. Reverse dark brown (6F8) surrounded by greyish brown (6D3), with orange white (6A2) at the margin.
MICROMORPHOLOGY: Hyphae (1.3-)2.0-3.9(-4.5) rarely up to 7.1 um in diameter, hyaline, lacking clamp connections.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), casamino acids degradation (-), acidification of BCP-casamino acids agar (-), urease activity (-, with growth), sensitive at 7°C, sensitive at 30°C, tolerant to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), semi-tolerant to rose bengal (10ug/mL), tolerant to malachite green (2ug/mL), tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (negative), DBB reaction on non-treated

mycelia (negative).
HABITAT: in moist coniferous forests (under *Picea* and *Abies*) in the boreal forest zone of eastern Canada and adjacent USA (Pomerleau and Smith 1962; Snell and Dick 1970).
ISOLATE EXAMINED: CANADA: QUEBEC: Mistassini Territory, Baie James, under *Picea mariana* and *Pinus banksiana*, 1.x.82, B.McAfee CRBF 185.
REMARKS: No further differentiation between *S.glandulosus* and *S.sinuspaulianus* was possible. As Pomerleau and Smith (1962) point out, these two species are closely related and share the same hosts and range.

8. *Suillus granulatus* (L.: Fr.) Roussel
MACROMORPHOLOGY: BAF: circular to irregularly circular, 28-50 mm in diameter, cottony to floccose to subfelty, sometimes matted, lacunose, beige (4C3) to greyish brown (5D3-5E3) in centre or mottled with white, white at an appressed to raised ±even margin. Reverse yellowish brown (5E8-5F8) to dark brown (6F8) in centre, with pale yellow (4A3) to light yellow (4A5) at the margin, radial grooves visible below the colony. Sometimes light pigment diffusing into the agar. PDA: circular, 34-43 mm in diameter, cottony to floccose to felty, sometimes matted, lacunose, dark grey (F1) to orange grey (5B2) to brownish grey (4E2) in centre or mottled together with white, white to pale grey (B1) at an appressed to raised even margin. Reverse brown (6E8) to dark brown (6F8) in centre, surrounded by brown (7E8) to greyish brown (6E3) or mottling of two, with pale orange (5A3) to yellowish white (3A3) at the margin. Light pigment often diffusing into the agar. MN: circular, 40-52 mm in diameter, cottony, often lacunose, brownish orange (5C3) to brown (6E4) in centre, white elsewhere, with a raised even margin. Reverse yellowish brown (5F8) to brown (7E6) in centre, surrounded by dark brown (7F8-8F8), with pale yellow (4A3) to light yellow (4A5) at the margin, radial grooves visible from below colony when lacunose. Hagem's: circular to slightly irregularly circular, 37-46 mm in diameter, cottony, sometimes lacunose, white, rarely brownish grey (5C2) in centre, with a raised even to uneven margin. Reverse yellowish brown (5F8) to dark brown (6F8) under plug, rest of colony greyish orange (5B4-6B4) with light orange (5A4) at the margin, radial grooves visible from below colony when lacunose, sometimes resulting in cracking of the agar.
MICROMORPHOLOGY: Hyphae (1.3-)2.0-3.9(-5.2) um in diameter, hyaline, lacking clamp connections, although rarely a few clamp connections may be found, and producing a few hyphal swellings when grown on modified Hagem's.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), casamino acids degradation (-), acidification of BCP-casamino acids agar (-), urease activity (-, with growth), sensitive at 7°C, tolerant at 30°C, tolerant to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), sensitive to tolerant to malachite green (2ug/mL), tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (negative), DBB reaction on non-treated mycelia (yellow).
HABITAT: in coniferous forests under *Pinus* throughout North America (Snell and Dick 1970; Smith and Thiers 1971; Thiers 1975; Miller 1980; McKnight and McKnight 1987).

ISOLATES EXAMINED: SOUTH KOREA: east of Mt. Odae National Park, under Pinus densiflora among mixed hardwoods and conifers, 30.viii.85, O.K.Miller UAMH 6204; Mt. Geryong National Park, under Pinus densiflora and mixed hardwoods, 6.ix.85, O.K.Miller UAMH 6203.
LITERATURE REPORTS OF CULTURAL CHARACTERS: Melin (1923a), Hatch and Hatch (1933), Pantidou and Groves (1966), Miller et al. (1983), Besl et al (1989).
REMARKS: Fries and Neumann (1990) had shown that S.granulatus was bipolar heterothallic. They suggested that isolates from North America may represent a taxon different from the one recognized in Europe as S.granulatus.

9. Suillus grevillei (Kl.: Fr.) Singer (syn. Boletus elegans Schum.: Fr.)
MACROMORPHOLOGY: BAF: ± circular to sometimes polygonal, 25-56 mm in diameter, cottony to floccose, rarely felty, rarely lacunose, mycelium often reaching lid of petri dish, producing dark coloured droplets on surface, white, sometimes with pale yellow (4A3) to greyish brown (5D3) in centre, with a raised even margin. Reverse violet brown (10F8) to black in centre surrounded by brownish red (10D8) to violet brown (10F8), sometimes orange (5A6-6B7) at the margin. Opaque brown pigment forming halo around the colony. PDA: ± circular, (26-)36-66 mm in diameter, cottony, sometimes lacunose, producing dark droplets on surface, white, sometimes yellowish white (4A2) to greyish orange (5B3) in centre, with a raised even margin. Reverse violet brown (10F8) to black in centre surrounded by violet brown (10E8-11E8), with brownish orange (6C8) to reddish brown (9D6) at the margin. Dark brown pigment diffusing into the agar. MN: circular to slightly irregularly circular (sometimes polygonal), (34-)57-74 mm in diameter, cottony, mycelium often touching lid of petri dish, sometimes producing honey coloured droplets on surface, white, sometimes pale yellow (4A3) to orange white (6A2) in centre, with a raised ± even to uneven margin. Reverse dark brown (7F8-8F8) to black in centre, surrounded by light brown (7D7) to brown (7E8), with greyish orange (6B5) to brownish orange (6C4) at the margin. Faint brown (rarely dark brown) pigment diffusing into the agar. Hagem's: circular to slightly irregularly circular, (36-)44-73 mm in diameter, cottony, mycelium often touching lid of petri dish, producing light brown droplets on surface, white, sometimes yellowish white (4A2) to greyish orange (5B3) in centre, with a raised ± even margin. Reverse dark brown (6F8) to violet brown (10F8) under plug, surrounded by brown (7E8) to deep red (10C8) then light orange (5A5-6A4) to orange (4A4), with orange white (5A2) to pale orange (5A3) at the margin. Rarely light brown pigment diffusing into the agar.
MICROMORPHOLOGY: Hyphae (1.3-)2.0-3.2(-4.2) rarely up to 5.2 um in diameter, hyaline, lacking clamp connections.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), casamino acids degradation (-), acidification of BCP-casamino acids agar (-), urease activity (variable), sensitive at 7°C, sensitive to semi-tolerant at 30°C, tolerant to benomyl (10ug/mL), sensitive to semi-tolerant to cycloheximide (2ug/mL), sensitive to tolerant to rose bengal (10ug/mL), tolerant to malachite green (2ug/mL), tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (negative), DBB reaction on non-treated mycelia (negative).

HABITAT: under *Larix* throughout its range in North America (Smith and Thiers 1971; Thiers 1975; Miller 1980; Lincoff 1981).
ISOLATES EXAMINED: CANADA: MANITOBA: Winnipeg, University of Manitoba campus, beneath *Larix laricina* and *Picea glauca* in small plantation, 28.viii.87, L.J.Hutchison UAMH 6160; ONTARIO: Timiskaming District, Burt Twp., Burt Lake, under *Larix laricina*, August 1980, D.G.Lahaie UAMH 6161; QUEBEC: Nouveau Québec Territory, 5.7 km NW of Schefferville, in moss beneath *Larix laricina*, 5.ix.84, L.J.Hutchison UAMH 5924.
LITERATURE REPORTS OF CULTURAL CHARACTERS: Melin (1922), How (1940), Sobotka (1954), Mikola (1955). Pantidou and Groves (1966), Besl *et al*. (1989).
REMARKS: *Suillus grevillei* is a variable species in culture as Pantidou and Groves (1966) pointed out. They even suggested that *S.grevillei* may consist of a species complex.

10. *Suillus luteus* (L.: Fr.) Roussel

MACROMORPHOLOGY: BAF: circular to slightly irregularly circular, 37-49 mm in diameter, cottony to subfelty, very lacunose, greyish orange (6B3) to greyish brown (8E3) in centre, white at the raised even margin. Reverse dark brown (6F5-7F8) in centre, with light orange (5A5) to orange (6B7) at the margin, radial grooves visible from beneath the colony and often causing cracking of the agar to occur. Slight pigment diffusing into the agar. PDA: circular to slightly irregularly circular, 31-48 mm in diameter, cottony, lacunose, often producing black droplets on surface, white becoming brownish orange (5C4) to brown (7E4) in centre, with a raised to appressed ±even margin. Reverse dark brown (8F8) to violet brown (10F8) in centre, surrounded by brown (7E5-7E8), with light yellow (4A4) to orange (5A6) at the margin, radial grooves visible from beneath colony often causing the agar to crack. Light to dark brown pigment diffusing into the agar. MN: irregularly circular to irregular, 32-40 mm in diameter, cottony, sometimes felty, lacunose, brownish orange (6C3) to greyish brown (5D3) in centre, white at the raised ±even margin. Reverse greyish brown (6E3) to dark brown (6F8) in centre, mottled with greyish orange (5C5) to brownish orange (6C4), with yellowish white (4A2) to light orange (5A4) at the margin, sometimes slight cracking of agar occurring beneath the colony. Hagem's: irregularly circular, 27-43 mm in diameter, cottony, slightly lacunose, white with yellowish white (4A2) to pale yellow (4A3) in centre, with a raised to appressed ±even margin. Reverse dark brown (6F8) under plug surrounded by light orange (6A5) to reddish brown (8E6), with yellowish white (4A2) to orange white (5A2) at the margin.
MICROMORPHOLOGY: Hyphae (1.3-)2.0-4.2(-5.2) um in diameter, hyaline, lacking clamp connections, although they may occasionally be present.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), casamino acids degradation (-), acidification of BCP-casamino acids agar (-), urease activity (-, growth present/absent), sensitive at 7°C, tolerant at 30°C, tolerant to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), tolerant to malachite green (2ug/mL), tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (negative), DBB reaction on non-treated mycelia (red).
HABITAT: in coniferous woods under *Pinus*, throughout North America (Snell and Dick 1970; Thiers 1975; Miller 1980; McKnight and McKnight 1987)

ISOLATE EXAMINED: CANADA: ONTARIO: York Co., Whitchurch Conservation Area nr. Ballantrae, under Pinus strobus, 23.x.83, E.Schwärtzel UAMH 6058.
LITERATURE REPORTS OF CULTURAL CHARACTERS: Melin (1923a), Masui (1927), Hatch and Hatch (1933), Khudyakov and Voznyakovskaya (1951), Sobotka (1954), Mosca and Fontana (1965), Pantidou and Groves (1966), Kowalski (1974), and Besl et al. (1989).
REMARKS: Fries and Neumann (1990) found that S.luteus was bipolar heterothallic and that North American and European monokaryotic strains were intercompatible. They reported that the presence of clamp connections in their dikaryotic cultures was variable and in addition, monokaryotic cultures differed in morphology from dikaryotic cultures.

11. Suillus neoalbidipes Palm & Stewart [syn. Suillus albidipes (Peck) Singer sensu Smith and Thiers (1971)]
MACROMORPHOLOGY: BAF: ± circular, 46-60 mm in diameter, cottony, producing light brown droplets over entire surface, white, sometimes brownish grey (6C2) to brown (6E8) in centre, with a raised even margin. Reverse dark grey (F1) to dark brown (7F5) in centre surrounded by reddish brown (9E8) to violet brown (11E8), with reddish orange (7A6) to brownish orange (7C8) at the margin. Opaque brown pigment diffusing into agar sometimes forming halo around colony. PDA: circular, 52-60 mm in diameter, cottony, producing light to dark coloured droplets on surface, white to orange white (5A2), with a raised ±even margin. Reverse dark ruby (12F8) to black in centre surrounded by violet brown (10E8), with brownish red (8C8) at the margin. Dark brown pigment diffusing into the agar. MN: circular, 61-72 mm in diameter, cottony, producing clear droplets over entire surface, white, sometimes greyish orange (6B2) in centre, with a raised to almost appressed even margin. Reverse greyish brown (6D3) to dark brown (8F8) in centre, surrounded by reddish brown (8E8) to violet brown (10E8), with greyish orange (6B4) to brownish orange (6C7) at the margin. Very light brown pigment diffusing into the agar. Hagem's: circular to slightly irregularly circular, 49-66 mm in diameter, cottony, producing clear droplets of liquid on surface, white with a raised ±even margin. Reverse dark brown (7F8) under plug surrounded by brownish orange (7C8) to brownish red (10D8), with light orange (5A4) at the margin.
MICROMORPHOLOGY: Hyphae 2.0-4.5(-5.8) um in diameter, hyaline, lacking clamp connections, producing globose to ellipsoidal swellings 8.5-18.8 x 13.0-26.0 um when grown on Hagem's.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-), urease activity (-, growth present), sensitive at 7°C, tolerant at 30°C, tolerant to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), tolerant to malachite green (2ug/mL), semi-tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (negative), DBB reaction on non-treated mycelia (negative).
HABITAT: in coniferous woods under Pinus, particularly in plantations of Pinus strobus, throughout North America (Snell and Dick 1970; Smith and Thiers 1971; Thiers 1975; McKnight and McKnight 1987).
ISOLATE EXAMINED: CANADA: ONTARIO: Timiskaming District, Burt Twp., Burt Lake, under Pinus banksiana, Picea glauca, Betula papyrifera and Salix sp., 24.viii.80, D.G.Lahaie UAMH 6158.

LITERATURE REPORTS OF CULTURAL CHARACTERS: Pantidou and Groves (1966).
REMARKS: Palm and Stewart (1984) pointed out that the type specimen of *S.albidipes* consisted of *S.granulatus* specimens, but that the species concept of most authors for *S.albidipes* was different. Hence, *S.neoalbidipes* was proposed as a new species for the taxon previously referred to as *S.albidipes*.

12. *Suillus ochraceoroseus* (Snell) Singer
MACROMORPHOLOGY: BAF: irregularly circular, 19-35 mm in diameter, cottony to felty, sometimes woolly, lacunose, often producing minute black droplets on surface, light brown (6D6) in centre, white to yellowish white (4A2) at the raised even margin. Reverse dark brown (6F8-8F8) in centre, surrounded by reddish brown (9E8) to violet brown (10E8), with reddish orange (7A8) to reddish brown (8D8) at the margin. Opaque reddish brown to brownish orange pigment forming halo around the colony. PDA: slightly irregularly circular, 23-38 mm in diameter, woolly to felty, sometimes sectoring, lacunose, producing minute black droplets on surface, light brown (6D6) to dark brown (6F8) in centre, sometimes surrounded by yellowish brown (5E4), greyish beige (4C2) if sectors produced, agar sometimes depressed around an appressed even margin. Reverse black. Very dark and intense reddish brown pigment diffusing into the agar. MN: circular to irregularly circular, 18-35 (-50) mm in diameter, cottony to woolly to felty, lacunose, white, sometimes pale yellow (4A3) mottled with brown (6E8), with a raised even margin. Reverse dark brown (8F8-9F8) in centre surrounded by reddish brown (9E8), with reddish orange at margin. Dark orange to reddish brown pigment diffusing into the agar. Hagem's: irregularly circular, 27-32 mm in diameter, cottony to felty sometimes woolly, lacunose, white to pale yellow (4A3), with a raised ± uneven margin. Reverse dark brown (6F8-8F8) in centre, sometimes surrounded by reddish brown (9E8) with orange (5A7-6B8) at the margin, agar cracking under colony. Light orange pigment diffusing into the agar.
MICROMORPHOLOGY: Hyphae 2.0-4.2(-6.5) um in diameter, hyaline, lacking clamp connections.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-), urease activity (variable, growth absent), sensitive to semi-tolerant at 7°C, tolerant at 30°C, tolerant to benomyl (10ug/mL), sensitive to semi-tolerant to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), tolerant to malachite green (2ug/mL), tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (negative), DBB reaction on non-treated mycelia (red).
HABITAT: under *Larix*, particularly *L.occidentalis* in the Pacific Northwest of USA and adjacent Canada (Pomerleau and Smith 1962; Miller 1980; Lincoff 1981; McKnight and McKnight 1987).
ISOLATES EXAMINED: CANADA: ALBERTA: Devon, Devonian Botanic Garden, under *Larix laricina*, 8.ix.85, R.S.Currah UAMH 5286; Rocky-Clearwater Forest, under *Larix* in mixed *Picea glauca* and *P.mariana* woods, 28.vii.86, R.S.Currah UAMH 5446.
LITERATURE REPORTS OF CULTURAL CHARACTERS: Laut (1966).
REMARKS: Laut (1966) reported clamp connections as common to abundant while Samson and Fortin (1988) also recorded clamp connections for this species. Clamps were absent from cultures in the present study and were reported as absent from basidiomata (Pomerleau and Smith 1962).

13. Suillus sinuspaulianus (Pomerleau & A.H.Smith) Dick & Snell
MACROMORPHOLOGY: BAF: irregularly circular, 24-26 mm in diameter, felty to appressed, radially lacunose, light brown (6D4) to dark brown (6F8) in centre surrounded by yellowish grey (4C4), whitish at a raised even margin. Reverse dark brown (9F8). Brown pigment diffusing into the agar. PDA: irregularly circular, 30-39 mm in diameter, felty to cottony, lacunose, producing brown to honey-coloured droplets on surface, beige (4C3) to brown (7E8), whitish at a raised even margin. Reverse black if pigment production intense otherwise black surrounded by violet brown (10F8) with deep orange (6A8) at the margin. Brown pigment diffusing into agar, in some cases an intensely dark red pigment forming halo around the colony. MN: circular to slightly irregular, (40-)52-69 mm in diameter, cottony, slightly depressed in centre, producing droplets of water on surface, sometimes greyish yellow (4C4) in centre, elsewhere whitish, with a raised even margin. Reverse black surrounded by violet brown (10F8) then brownish orange (7C7), with orange (5A6) at the margin. Light brown pigment diffusing into the agar. Hagem's: circular, 68-72 mm in diameter, cottony, producing scattered honey-coloured droplets over surface, sometimes yellowish brown (5D4) in centre, elsewhere pale yellow (4A3), with a raised even margin. Reverse violet brown (10F8) surrounded by mottling of violet brown (10E8) and greyish red (8C5) with orange (5A6) at the margin. Light brown pigment diffusing into the agar.
MICROMORPHOLOGY: Hyphae (1.3-)1.6-3.2 rarely up to 3.9 um in diameter, hyaline, lacking clamp connections.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-), urease activity (-, growth present), sensitive at 7°C, sensitive at 30°C, tolerant to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), tolerant to malachite green (2ug/mL), tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (negative).
HABITAT: in coniferous woods (under Picea and Abies) in the boreal forest zone of eastern Canada (Pomerleau and Smith 1962; Miller 1980).
ISOLATE EXAMINED: CANADA: NEWFOUNDLAND: Labrador, 19 km S of Schefferville at Howell's River, in deep moss under Picea mariana and Larix laricina, 24.viii.84, D.W.Malloch UAMH 6147.
LITERATURE REPORTS OF CULTURAL CHARACTERS: Pantidou and Groves (1966).
REMARKS: S.sinuspaulianus is indistinguishable in vitro from the closely related Suillus glandulosus.

14. Suillus spectabilis (Peck) Singer
MACROMORPHOLOGY: BAF: circular, 32-38 mm in diameter, cottony to felty, lacunose, greyish brown (5D3) with white at an appressed to slightly raised even margin. Reverse dark brown (6F8) surrounded by brown (6E8), agar cracking beneath the colony. Opaque yellowish brown pigment forming halo around the colony. PDA: circular, 33-42 mm in diameter, cottony to felty, producing very tiny black droplets on surface, lacunose, zonation similar to that of basidiomata of Trametes versicolor, brownish orange (5C3) alternating with greyish yellow (4B3) with white at a raised even margin. Reverse violet brown (10F8) to black in centre with brownish red (8C8) at the margin. Intense reddish brown pigment diffusing into the agar. MN: circular, 33-40 mm in diameter, cottony to felty, lacunose, brownish orange (5C3) in centre,

with white at a raised even margin. Reverse violet brown (10F8) in centre with brownish red (8C8) at the margin. Brown pigment diffusing into the agar. Hagem's: ± circular, 28-36 mm in diameter, cottony to felty, lacunose, white to yellowish white (4A2), sometimes with olive brown (4E3) at a raised even margin. Reverse dark brown (9F8) in centre with reddish orange (7B8) at the margin, with agar cracking beneath the colony. Slight pigment diffusing into the agar.

MICROMORPHOLOGY: Hyphae (1.6-)2.0-3.9(-4.5) um in diameter, hyaline, lacking clamp connections.

PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-), urease activity (-, growth absent), sensitive at 7°C, tolerant at 30°C, tolerant to benomyl (10ug/mL), semi-tolerant to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), tolerant to malachite green (2ug/mL), tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (negative), DBB reaction on non-treated mycelia (red).

HABITAT: under *Larix laricina* in boreal forest of eastern Canada and adjacent United States (Pomerleau and Smith 1962; Snell and Dick 1970; Smith and Thiers 1971; Miller 1980).

ISOLATE EXAMINED: CANADA: QUEBEC: Nouveau Québec Territory, 4.5 km NE of Schefferville, in *Pleurozium* moss under *Larix laricina*, 30.viii.84, D.W.Malloch UAMH 6148.

LITERATURE REPORTS OF CULTURAL CHARACTERS: Pantidou (1961).

15. *Suillus spraguei* (Berk. & Curt.) Kuntze [syn. *Suillus pictus* (Peck) A.H.Smith & Thiers]

MACROMORPHOLOGY: BAF: polygonal to star-shaped, 35-42 mm in diameter, floccose in centre, rest of colony subfelty, lacunose, greyish orange (5B5), whitish at a raised even margin. Reverse greyish brown (6F3) in centre surrounded by reddish brown (8D8). Dense opaque brownish pigment diffusing into the agar. PDA: circular, 39-46 mm in diameter, floccose, subfelty towards margin, light yellow (4A4) in centre and surrounded by yellowish brown (5E4) with light yellow (4A4) at a raised even margin. Reverse violet brown (10F8) in centre surrounded by brownish red (10D8) with reddish orange (7A8) at the margin. Brown pigment diffusing into the agar. MN: slightly irregularly circular, 51-56 mm in diameter, felty to subfelty, beige (4C3) in centre surrounded by pale yellow (4A3) with white to brownish grey (5E2) at a raised even margin. Reverse dark brown (9F8) surrounded by reddish brown (8D8) to greyish red (7B6) at the margin. Light pigment diffusing into the agar. Hagem's: circular, 33-55(-67) mm in diameter, cottony to subfelty, lacunose, pale yellow (4A3) with white at a raised even margin. Reverse brown (7E7) in centre surrounded by light orange (5A4) with yellowish white (4A2) at the margin, radial grooves visible beneath colony, light orange (5A4) in colour.

MICROMORPHOLOGY: Hyphae (1.6-)2.0-5.2(-8.4) um in diameter, hyaline, lacking clamp connections.

PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-), urease activity (-, growth present), sensitive at 7°C, semi-tolerant at 30°C, tolerant to benomyl (10ug/mL), semi-tolerant to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), tolerant to malachite green (2ug/mL), tolerant to sodium chloride

(10mg/mL), polyphenol oxidase activity (negative), DBB reaction on non-treated mycelia (negative).
HABITAT: in coniferous and mixed woods under Pinus strobus, eastern North America (Snell and Dick 1970; Smith and Thiers 1971; Thiers 1975; Miller 1980; Lincoff 1981; McKnight and McKnight 1987).
ISOLATE EXAMINED: USA: MASSACHUSETTS: Worcester Co., Federation of Womens Club State Forest, under Pinus strobus, 9.viii.86, D.W.Malloch UAMH 5846.
LITERATURE REPORTS OF CULTURAL CHARACTERS: Pantidou (1961), Randall and Grand (1986).

16. Suillus subluteus (Peck) Snell
MACROMORPHOLOGY: BAF: irregularly circular, (35-)40-59 mm in diameter, cottony to felty, very lacunose, producing honey coloured droplets on surface, yellowish grey (4B2) to brownish grey (6C2) in centre, sometimes surrounded by light brown (7D6) to greyish red (7B4), with white at an appressed to slightly raised even margin, where agar is depressed. Reverse light brown (6D4) to brown (6E4) sometimes surrounded by light grey (D1), with light orange (5A4) to pale yellow (4A3) at the margin, intense cracking of agar below the colony. Slight pigment diffusing into the agar. PDA: circular, 45-57 mm in diameter, cottony to felty, producing dark droplets on centre of surface, dull white to brownish orange (5C3), with an appressed to slightly raised even margin. Reverse brown (6E8) to dark grey (F1) in centre, surrounded by brownish orange (6C8) to violet brown (11F8), with orange (5A7-6A6) at the margin, agar sometimes cracking below the colony. Light to dark brown pigment diffusing into the agar. MN: circular, usually but not always covering the plate, white, with a raised even margin. Reverse brown (6E5) to reddish brown (9E8) in centre, surrounded by light orange (5A4) to orange grey (5B2), with yellowish white (4A2) to pale orange (5A3) at the margin. Hagem's: circular, (49-)70-80 mm in diameter, cottony to felty, rarely lacunose, producing water droplets on surface, white, with a raised even margin. Reverse brown (7E5) to reddish brown (8C8) in centre, sometimes surrounded by pastel red (7A5), with orange white (5A2-6A2) at the margin, agar cracking below colony when lacunose.
MICROMORPHOLOGY: Hyphae (1.6-)2.0-3.2(-5.2) rarely up to 7.1 um in diameter, hyaline, lacking clamp connections.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-), urease activity (+, growth absent), sensitive at 7°C, tolerant at 30°C, tolerant to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), tolerant to malachite green (2ug/mL), tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (negative), DBB reaction on non-treated mycelia (negative).
HABITAT: under Pinus banksiana in boreal forest, eastern North America (Smith and Thiers 1971; Thiers 1975; Miller 1980).
ISOLATE EXAMINED: CANADA: ONTARIO: Timiskaming District, Burt Twp., Burt Lake, under Pinus banksiana, 26.viii.83, E.Schwärtzel UAMH 6059.

17. Suillus tomentosus (Kauffman) Singer, Snell & Dick
MACROMORPHOLOGY: BAF: circular to irregularly circular (rarely polygonal), (25-)30-52(-64) mm in diameter, cottony to woolly, frequently felty, lacunose, brownish orange (5C4) to brown (6E8) in

centre, white elsewhere, agar depressed at a raised to appressed even margin. Reverse greyish brown (5E3-6E3) to dark brown (6F8-7F8) in centre surrounded by light brown (7D8) to brown (7E8) through to reddish brown (8E8-9D8), with reddish orange (7A8) to brownish orange (6C7-6C8) at the margin, radial grooves often visible beneath colony, agar cracking beneath colony. Opaque orange brown to reddish brown pigment forming halo around the colony. PDA: circular to slightly irregularly circular, (25-)35-56(-63) mm in diameter, cottony to rarely woolly, rarely lacunose, usually producing dark brown droplets on surface, greyish orange (6B4) to brown (6E6-6E8) in centre with white to greyish yellow (4B3) at a raised to appressed even margin. Reverse dark brown (6F8-8F8) to black in centre, surrounded by brown (7E8) to violet brown (10E8), with brownish orange (7C8) to light orange (5A5) at the margin, radial grooves visible beneath colony when lacunose often resulting in agar cracking below the colony. Reddish brown to orange brown pigment diffusing into the agar. MN: circular to slightly irregularly circular, (33-)42-70(-75) mm in diameter, cottony, sometimes sparsely cottony at margin, rarely lacunose, occasionally producing a few dark droplets on surface, mycelium sometimes touching lid of petri dish, white, rarely pale yellow (4A3) to greyish orange (5B3) in centre, with a raised to appressed even to uneven margin. Reverse brown (6E4) to dark brown (6F8-9F8) in centre surrounded by brownish orange (5C6-6C6) to light brown (6D5-6D8) through to brown (7E8), with yellowish white (4A2) to greyish orange (6B5) at the margin, radial grooves visible beneath colony when lacunose. Very slight brown to yellowish pigment diffusing into the agar. Hagem's: circular to irregularly circular, (27-)38-70 mm in diameter, cottony, rarely lacunose, mycelium sometimes reaching lid of petri dish, white, rarely light yellow (4A4) to greyish yellow (4B5) in centre, with a raised to appressed even to uneven margin. Reverse greyish brown (6E3-7E3) to reddish brown (8E4-8E8) in centre, surrounded by light orange (5A4-6A4) to reddish brown (8D8), with yellowish white (4A2) to light orange (5A4-6A5) at the margin, radial grooves visible beneath colony when lacunose and often resulting in cracking of agar below the colony.

MICROMORPHOLOGY: Hyphae (1.3-)2.0-4.2(-5.2) rarely up to 6.5 um in diameter, hyaline, lacking clamp connections, rarely producing swellings when submerged.

PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-), urease activity (-, growth present), sensitive at 7°C, tolerant at 30°C, tolerant to benomyl (10ug/mL), mostly sensitive but sometimes tolerant to cycloheximide (2ug/mL), variable response to rose bengal (10ug/mL), tolerant to malachite green (2ug/mL), tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (negative; rarely tyrosinase dominant), DBB reaction on non-treated mycelia (yellow).

HABITAT: under two-needled pines, particularly *Pinus contorta* in western North America and under *Pinus banksiana* in boreal forest zone of eastern North America (Snell and Dick 1970; Smith and Thiers 1971; Thiers 1975; Miller 1980; Lincoff 1981; McKnight and McKnight 1987).

ISOLATES EXAMINED: CANADA: ALBERTA: Edson Forest, under *Pinus contorta*, 2.ix.85, R.S.Currah UAMH 5205; Slave Lake Forest, under *Pinus contorta* and *Picea glauca*, 2.ix.85, R.S.Currah UAMH 5211, 4.ix.85, R.S.Currah UAMH 5227; Devon, Devonian Botanic Garden, under *Pinus banksiana*, 8.ix.85, R.S.Currah UAMH 5291; Rocky-Clearwater Forest, under *Pinus contorta* and *Picea mariana*, 28.vii.86, R.S.Currah UAMH 5550; MANITOBA: Reynolds Local Government District, Sandilands Provincial Forest, under *Pinus banksiana*, 27.viii.87, L.J.Hutchison UAMH 6060; ONTARIO: Timiskaming District, Burt Twp., Burt Lake, under *Pinus banksiana*, *Picea glauca* and *Abies balsamea*, 19.viii.86, L.J.Hutchison UAMH 5795; 2.5 km W of Burt Lake, under *Pinus banksiana*, 20.viii.86, L.J.Hutchison UAMH 5918.

LITERATURE REPORTS OF CULTURAL CHARACTERS: Pantidou and Groves (1966), Miller *et al*. (1983).

REMARKS: The mycelium of *Suillus tomentosus* stains yellow with diazonium blue B rendering it similar only to *Suillus granulatus*, the only other pine-associated *Suillus* likely to be found on 2-needled pines. *S.tomentosus* is closely related to the European species *Suillus variegatus* (Swartz: Fr.) Kuntze, which Smith and Thiers (1971) hinted may be conspecific. Cultural descriptions of *S.variegatus* have been reported in the literature (Melin 1923a; Khudyakov and Voznyakovskaya 1951; Sobotka 1954; Gnutenko and Pankova 1955; Mikola 1955; Pachlewski 1967; Kowalski 1974; Besl *et al*. 1989).

Miller *et al*. (1983) claimed arthrospores were developed in older colonies but these were misinterpretations of non-reproductive structures. Cultures of boletes undergo autosenescence very quickly because of the toxic nature of their phenolic pigments and undoubtedly what were seen were fragments of hyphae in the process of autosenescence.

18. *Suillus umbonatus* Dick & Snell

MACROMORPHOLOGY: BAF: circular to slightly irregularly circular, (32-)37-56 mm in diameter, sparsely cottony to cottony, sometimes lacunose, mycelium often reaching lid of petri dish, occasionally producing light brown droplets on surface, brownish orange (5C3) to light brown (6D6-7D5) in centre with white to yellowish white (4A2) at a raised even to uneven margin where agar is rarely depressed. Reverse dark brown (6F8-8F8) to violet brown (10F8) in centre surrounded by brown (6E8) to brownish red (10D8), with light orange (5A5) to light brown (7D8) through to reddish brown (8E8) at the margin, radial grooves visible from beneath colony when lacunose often resulting in cracking of agar below the colony. Opaque orange brown pigment forming halo around the colony. PDA: ±circular to slightly irregularly circular (slightly polygonal), (27-)36-53 mm in diameter, woolly to cottony, sometimes felty, lacunose, producing brown to dark brown droplets on surface, greyish orange (6B4) to light brown (6D5) through to dark brown (6F5) in centre, surrounded by medium grey (E1) to brown (7E6), with white to light grey (D1) at an appressed to raised even to uneven margin. Reverse dark brown (6F8-8F8) to black in centre surrounded by greyish brown (7F3) to reddish brown (8D8-9E8), with light orange (5A4-6A5) to brownish red (8B8-8C8) at the margin, radial grooves visible from beneath colony. Orange brown to reddish brown pigment diffusing into the agar. MN: circular to slightly irregularly circular, (41-)49-72 mm in diameter, cottony to sparsely cottony, rarely felty, mycelium reaching lid of petri dish, yellowish white (4A2) to greyish orange (6B3) in centre, whitish towards an appressed to raised even to uneven margin. Reverse brown (6E8) to dark brown (6F8-7F8) in centre, surrounded by light brown (6D8) to dark brown (7F8-8F4), with yellowish

white (4A2) to orange white (5A2) rarely brownish orange (7C4) at the margin, radial grooves occasionally visible from beneath the colony. Very slight pigment rarely diffusing into the agar. Hagem's: circular to irregularly circular (slightly polygonal), (34-)52-78 mm in diameter, cottony to sparsely cottony, mycelium touching lid of petri dish, rarely lacunose, white, sometimes greyish yellow (4B3) in centre, with a raised even to uneven margin. Reverse brownish grey (6D2) to dark brown (6F8) in centre surrounded by light brown (6D8) to brown (6E8) through to brownish red (10D8), with pale yellow (4A3) to pale orange (5A3-6A3) at the margin, radial grooves visible from beneath the colony when lacunose.
MICROMORPHOLOGY: Hyphae 2.0-4.2(-5.2) rarely up to 7.1 um in diameter, hyaline, lacking clamp connections.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (+), urease activity (-, growth present or absent), sensitive at 7°C, variable at 30°C, tolerant to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), tolerant to malachite green (2ug/mL), tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (tyrosinase dominant, rarely negative), DBB reaction on non-treated mycelia (negative).
HABITAT: in sphagnum under *Pinus contorta* and to a lesser extent *Pinus banksiana*, primarily but not exclusively in western North America (Snell and Dick 1970; Thiers 1975; Miller 1980; McKnight and McKnight 1987).
ISOLATES EXAMINED: CANADA: ALBERTA: Edson Forest, in *Pinus contorta* woods, 9.ix.85, R.S.Currah UAMH 5242; Grande Prairie Forest, in *Pinus contorta* woods, 9.ix.85, R.S.Currah UAMH 5309; Rocky-Clearwater Forest, under *Pinus contorta*, *Picea glauca*, *Picea mariana* and *Populus* sp., 28.vii.86, R.S.Currah UAMH 5461, 6.viii.86, R.S.Currah UAMH 5549.
LITERATURE REPORTS OF CULTURAL CHARACTERS: Pantidou and Groves (1966).
REMARKS: *Suillus umbonatus* was unique among the *Suillus* species examined in this present study by acidifying BCP-casamino acid agar after 12 weeks.

19. *Suillus viscidus* (L.: Fr.) Roussel [syn. *Suillus aeruginascens* (Secr.) Snell]
MACROMORPHOLOGY: BAF: slightly irregularly circular to irregularly circular, 34-36 mm in diameter, cottony, greyish brown (5E3) mixed with white, with a ± raised even margin. Reverse black under plug, surrounded by dark brown (8F8) then by brown (7E8), with light orange (6A4) at the margin. Light orange brown pigment diffusing into agar. PDA: moderately irregularly circular, 32-38 mm in diameter, felty, greyish orange (5B3) surrounded by reddish brown (9D4), appressed ±even margin. Reverse dark brown (9F8) surrounded by reddish brown (9E8), with greyish red (8C4) at margin. Orange brown pigment diffusing into the agar. MN: irregularly circular, (17-)29-32 mm in diameter, felty to cottony, ±whitish with patches of beige (4C3), with a raised to appressed even margin. Reverse dark brown (7F8) in centre, surrounded by brown (7E8) then light orange (6A4), with yellowish white (4A2) at the margin. Hagem's: circular, 39-52 mm in diameter, cottony, mycelium reaching lid of petri dish, white, with a raised ±uneven margin. Reverse reddish brown (9D4) surrounded by reddish brown (9D8) then pale orange (5A3), with pale yellow (4A3) at margin.

MICROMORPHOLOGY: Hyphae 1.6-3.2(-4.5) um in diameter, hyaline, lacking clamp connections. A few oleiferous hyphae present.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-), urease activity (+, growth absent), sensitive at 7°C, sensitive at 30°C, tolerant to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), sensitive to rose bengal (10ug/mL), sensitive to malachite green (2ug/mL), semi-tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (tyrosinase dominant), DBB reaction on non-treated mycelia (negative).
HABITAT: in coniferous forests under *Larix* throughout the range of this genus in North America (Pomerleau and Smith 1962; Snell and Dick 1970; Smith and Thiers 1971; Miller 1980).
ISOLATE EXAMINED: CANADA: QUEBEC: Québec Co., Lac St.Charles, under *Larix laricina*, 26.ix.83, J.Samson CRBF 257.
LITERATURE REPORTS OF CULTURAL CHARACTERS: Pantidou and Groves (1966), Besl *et al*. (1989).

Xerocomus

Colonies white and cottony with dark brown pigments diffusing into the agar (BAF and PDA); primordia frequently produced by fresh isolates (Giltrap 1981; Pantidou 1964); hyphae lacking clamp connections; lipase (-), amylase (-), gelatinase (-), acidification of BCP-casamino acids agar (-), urease (+,growth absent); tolerant to benomyl, semi-tolerant to cycloheximide, sensitive to sodium chloride.

20. *Xerocomus badius* (Fr.) Kühner ex Gilbert

MACROMORPHOLOGY: BAF: circular to slightly irregularly circular, 28-42 mm in diameter, cottony, greyish yellow (4B4) to brownish orange (5C6) in centre, white elsewhere, with a raised even margin. Reverse dark brown (6F8) to violet brown (10E8) in centre, sometimes surrounded by brownish orange (7C8) with orange (5A6) at the margin, agar cracking below the colony. Dark brownish opaque pigment forming halo around the colony. PDA: ±circular, 26-42 mm in diameter, cottony (sparsely at times) to floccose, producing minute black droplets on surface, producing hyphal threads, greyish yellow (4B3-4B4) in centre, white elsewhere, with a raised to appressed even to uneven margin. Reverse dark brown (6F8-8F8) in centre, surrounded by brownish orange (6C6-7C8) at the margin. Brownish to dark orange brown pigment diffusing into the agar. MN: circular to slightly irregularly circular, (25-)35-63 mm in diameter, cottony, frequently producing hyphal threads, white with tinges of yellowish brown (5D4), with a raised, ± even margin. Revese dark brown (6F8-8F5) in centre surrounded by greyish orange (6B5) to brownish orange (6C8), with pale yellow (4A3) to light orange (5A5) at the margin. Sometimes orange brown pigment diffusing into the agar. Hagem's: ± circular to irregularly circular, 32-45(-52) mm in diameter, cottony, frequently producing hyphal threads, occasionally producing light coloured droplets on surface, white with patches of yellowish white (3A2) to yellowish brown (5D4) in centre with a raised even to uneven margin. Reverse brown (6E8) to dark brown (9F8) in centre surrounded by light orange (5A5) to brownish orange (6C7), with yellowish white (4A2) to pale yellow (4A3) at the margin.
MICROMORPHOLOGY: Hyphae (1.3-)2.0-3.9(-4.5) rarely up to 5.8 um in diameter, hyaline, lacking clamp connections, when submerged producing

globose to ellipsoidal swellings when grown on MN and Hagem's agar.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (+), acidification of BCP-casamino acids agar (-), urease activity (+, growth absent), sensitive at 7°C, sensitive at 30°C, tolerant to benomyl (10ug/mL), semi-tolerant to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), variable to malachite green (2ug/mL), sensitive to sodium chloride (10mg/mL), polyphenol oxidase activity (tyrosinase dominant), DBB reaction on non-treated mycelia (negative).
HABITAT: on ground or well rotted logs in coniferous or mixed woods of eastern deciduous hardwood forest zone, eastern United States and adjacent Canada (Snell and Dick 1970; Smith and Thiers 1971; Grund and Harrison 1976; Miller 1980; Lincoff 1981; McKnight and McKnight 1987).
ISOLATES EXAMINED: CANADA: NEW BRUNSWICK: Charlotte Co., St. Andrews Twp., Navy Island, under Pinus strobus, 24.viii.85, R.G.Thorn UAMH 5922; USA: MASSACHUSETTS: Franklin Co., Wendell State Forest, Ruggles Pond, under Pinus strobus, 9.viii.86, D.W.Malloch UAMH 5813.
LITERATURE REPORTS OF CULTURAL CHARACTERS: Melin (1923a), Sobotka (1954), Mikola (1955), Kowalski (1974), Besl et al. (1989).

21. Xerocomus subtomentosus (L.: Fr.) Quél.
MACROMORPHOLOGY: BAF: ± circular to slightly irregularly circular, 16-63 mm in diameter, cottony to sparsely cottony, white to pale yellow (4A3) with a raised ± even to uneven margin. Reverse dark brown (6F8) to reddish brown (8E8) in centre surrounded by brownish orange (7C8), with orange (6B7-6B8) at the margin. Light brown to orange brown pigment forming halo around the colony. PDA: slightly irregularly circular to irregularly circular, 15-60 mm in diameter, cottony to very sparsely cottony, pale orange (5A3) to greyish orange (5B3) in centre, with a raised uneven white margin. Reverse reddish brown (8E8) to violet brown (10E8) in centre surrounded by brownish orange (7C8), with orange (5B7) to greyish orange (6B6) at the margin. Slight pigment diffusing into the agar. MN: ± circular to irregularly circular, 15-72 mm in diameter, cottony to sparsely cottony, mycelium reaching lid of petri dish, blotches of greyish yellow (4B4) to greyish orange (5B4) in centre, whitish elsewhere, with a raised ± even to uneven margin. Reverse dark brown (6F8) to violet brown (10E8) in centre surrounded by orange (5B8) to brownish orange (6C8), with light yellow (4A5) to greyish orange (5B6) at the margin. Hagem's: circular to slightly irregular, 10-77 mm in diameter, often covering petri dish, cottony, mycelium sometimes touching lid of petri dish, light yellow (4A4) to greyish orange (6B4) in centre, white elsewhere, with a raised ± even to uneven margin. Reverse dark brown (6F8) to reddish brown (8E8) in centre surrounded by brownish yellow (5C8), with pale yellow (4A3) to light orange (5A4) at the margin.
MICROMORPHOLOGY: Hyphae (1.6-)2.0-3.9(-4.5) rarely up to 5.2 um in diameter, hyaline, lacking clamp connections.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-), urease activity (variable, growth absent),sensitive at 7°C, sensitive at 30°C, tolerant to benomyl (10ug/mL), semi-tolerant to cycloheximide (2ug/mL), variable response to rose bengal (10ug/mL), semi-tolerant to malachite green (2ug/mL), sensitive to sodium chloride (10mg/mL), polyphenol oxidase activity

(negative), DBB reaction on non-treated mycelia (red).
HABITAT: in deciduous, mixed and coniferous woods throughout temperate North America (Snell and Dick 1970; Lincoff 1981).
ISOLATES EXAMINED: CANADA: ONTARIO: Renfrew Co., nr. Barry's Bay, under Abies balsamea in mixed woods, 28.ix.86, F.Bruski UAMH 5818; Nipissing District, Algonquin Provincial Park, Canisbay Twp., in needle litter beneath Pinus strobus and Picea glauca, 3.x.87, L.J.Hutchison UAMH 5917.
LITERATURE REPORTS OF CULTURAL CHARACTERS: Modess (1941), Mikola (1955), Kowalski (1974), Besl et al. (1989).

22. Chalciporus piperatus (Bull.: Fr.) Bat.
MACROMORPHOLOGY: BAF: irregularly circular, 26-50 mm in diameter, appressed, lacunose, light brown (7D4), with an even to uneven margin. Reverse dark brown (6F8) under plug, surrounded by reddish brown (8E8) with light orange (6A4) at the margin, radial grooves visible beneath the colony. Brown pigment diffusing into the agar. PDA: irregularly circular due to sectoring, 36-39 mm in diameter, felty to appressed, lacunose, greyish yellow (4B3) where felty, brown (7E4) where appressed, with an appressed uneven margin. Reverse dark brown (7F4) in centre and in grooves, reddish brown (8E6) elsewhere, grooves visible beneath colony. Brown pigment diffusing into the agar. MN: irregularly circular, 5-7 mm in diameter, appressed, hyaline, with an even margin. Reverse greyish brown (8E3) under plug, pinkish white (8A2) elsewhere. Hagem's: very irregularly circular to irregular, 13-30 mm in diameter, felty, sectors sparsely flocculose, lacunose, whitish, sectors reddish brown (8E8), with an appressed uneven margin. Reverse dark brown (8F8) with reddish orange (7B7) at the margin. Slight orange pigment diffusing into the agar.
MICROMORPHOLOGY: Hyphae 1.3-2.9(-3.9) um in diameter, hyaline, lacking clamp connections, producing only a few swellings.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (+), gelatinase (+), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-), urease activity (+, growth absent), sensitive at 7°C, sensitive at 30°C, tolerant to benomyl (10ug/mL), semi-tolerant to cycloheximide (2ug/mL), sensitive to rose bengal (10ug/mL), sensitive to malachite green (2ug/mL), sensitive to sodium chloride (10mg/mL), polyphenol oxidase activity (negative), DBB reaction on non-treated mycelia (red).
HABITAT: coniferous forests throughout North America (Smith and Thiers 1971; Grund and Harrison 1976; Miller 1980; Lincoff 1981; McKnight and McKnight 1987).
ISOLATE EXAMINED: CANADA: ONTARIO: Simcoe Co., Adjala Twp., 4.5 km NW of Palgrave, in plantation of Pinus and Picea, 11.x.87, M.Silvera UAMH 6057.
LITERATURE REPORTS OF CULTURAL DESCRIPTIONS: Hatch and Hatch (1933), Modess (1941), Kowalski (1974), Besl et al. (1989).
REMARKS: Modess (1941) also recorded primarily submerged and appressed growth initially in cultures. However, he found that over time aerial mycelium developed and the growth rate increased. Giltrap (1981) reported that primordia formed on Hagem's agar in fresh isolates.

23. Boletus edulis Bull.: Fr.
MACROMORPHOLOGY: BAF: ± circular, 50-53 mm in diameter, cottony, mycelium reaching lid of petri dish, white, with a raised, ± even margin. Reverse

greyish brown (5E3) under plug, rest of colony greyish orange (5B3) with yellowish white (4A2) at the margin, radial grooves visible from beneath the colony. PDA: circular to slightly ellipsoidal, 52-55 mm in diameter, cottony, mycelium touching lid of petri dish, white, with a raised ±even margin. Reverse beige (4C3) in centre, surrounded by pale orange (5A3), with yellowish white (4A2) at the margin, a few radial grooves visible beneath the colony. MN: slightly irregularly circular to irregularly circular, (40-)53-56 mm in diameter, sparsely cottony in centre, rest of colony felty, mycelium touching lid of petri dish, white, with an appressed to raised ±even margin. Reverse yellowish brown (5F8) under plug, surrounded by pale yellow (4A3), yellowish white (4A2) elsewhere. Hagem's: ±circular to slightly irregularly circular, 47-50 mm in diameter, sparsely cottony, mycelium touching lid of petri dish, white, with an appressed to raised ±even margin. Reverse yellowish brown (5F8) under plug, surrounded by greyish orange (5B3) with orange white (5A2) at the margin.
MICROMORPHOLOGY: Hyphae (1.3-)2.0-3.9(-4.5) rarely up to 6.5 um in diameter, hyaline, lacking clamp connections.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-), urease activity (+, growth absent), sensitive at 7°C, sensitive at 30°C, tolerant to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), sensitive to rose bengal (10ug/mL), sensitive to malachite green (2ug/mL), sensitive to sodium chloride (10mg/mL), polyphenol oxidase activity (negative), DBB reaction on non-treated mycelia (red).
HABITAT: in coniferous forests throughout North America (Snell and Dick 1970; Smith and Thiers 1971; Harrison and Grund 1976; Miller 1980)
ISOLATE EXAMINED: CANADA: QUEBEC: Portneuf Co., St. Raymond, under *Picea glauca* and *P.mariana*, 20.ix.84, C.Godbout CRBF 332.
LITERATURE REPORTS OF CULTURAL CHARACTERS: Melin (1923b), Hatch and Hatch (1933), Modess (1941), Sobotka (1954), Mikola (1955), Kowalski (1974), Besl *et al*. (1989).
REMARKS: *Boletus edulis* produces white cottony mycelium *in vitro*, potentially confusing it with *Amanita*, *Tricholoma* and *Leccinum* species. However, all clampless *Amanita* produce amylase, differentiating them from *B.edulis*; the mycelia of all *Tricholoma* species stain yellowish with diazonium blue B while that of *B.edulis* stains red; and *Leccinum* species produce tyrosinase while *B.edulis* is negative for tyrosinase.

Sobotka (1954) reported a great number of densely packed tiny 'sclerotia' on the colonies. This could perhaps correlate with hyphal aggregations which occur on the surface of colonies after 2 months. Nevolin (1963) reported conidia in his isolate of *B.edulis* along with clamp connections indicating that he had a basidiomycetous contaminant.

24. *Boletus ornatipes* Peck

MACROMORPHOLOGY: BAF: circular to irregular, 13-27 mm in diameter, cottony, sometimes lacunose, pale yellow (4A3) to light yellow (4A4), agar slightly depressed around a raised even margin. Reverse dark brown (7F8-9F8) in centre surrounded by greyish orange (6B4-6B6), with orange white (5A2) at the margin. Slight brown pigment sometimes diffusing into the agar around the colony. PDA: circular to irregularly circular, 11-17 mm in diameter, cottony, lacunose, pale yellow (3A4) to light yellow (4A4) sometimes to yellowish brown (5D4), agar depressed at a

raised even margin. Reverse dark brown (6F8-7F8) with pale yellow (4A3) to light orange (5A5) at the margin, agar cracking below colony. Very faint brown pigment sometimes diffusing into agar. MN: circular to slightly irregularly circular, (7-)17-28 mm in diameter, slightly floccose to cottony, light yellow (4A4) to greyish orange (5B3) to even greyish brown (5D3), agar depressed at an appressed to raised even margin. Reverse dark brown (6F5-6F8) with yellowish white (4A2) to light yellow (4A5) at the margin, radial cracking of agar often occuring below the colony. Hagem's: circular to slightly irregularly circular, (10-)21-31 mm in diameter, cottony, pale yellow (4A3) to light yellow (4A4), with a raised even margin. Reverse brown (6E6) to dark brown (6F8) surrounded by light brown (6D8), with pale yellow (3A3) to yellowish white (4A2) sometimes even light orange (5A5) at the margin, cracking of agar beneath colony. Rarely slight brown pigment diffusing into the agar.
MICROMORPHOLOGY: Hyphae (1.0-)1.6-3.2(-3.9) rarely up to 5.9 um in diameter, hyaline, lacking clamp connections. Oleiferous hyphae occasionally present.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (+), amylase (-/+), gelatinase (+), degradation of casamino acids agar (-/+), acidification of BCP-casamino acids agar (-), urease activity (+, growth absent), sensitive at 7°C, sensitive at 30°C, tolerant to benomyl (10ug/mL), sensitive to semi-tolerant to cycloheximide (2ug/mL), variable response to rose bengal (10ug/mL), semi-tolerant to tolerant to malachite green (2ug/mL), sensitive to sodium chloride (10mg/mL), polyphenol oxidase activity (negative), DBB reaction on non-treated mycelia (negative/red).
HABITAT: associated with Fagus and Quercus (Fagaceae) in deciduous and mixed woods, eastern North America (Grund and Harrison 1976; Homola and Misretta 1977; Lincoff 1981; McKnight and McKnight 1987).
ISOLATES EXAMINED: CANADA: NOVA SCOTIA: Kings Co., Kentville, Agriculture Research Station ravine, under Fagus grandifolia and Tsuga canadensis, 29.viii.85, L.J.Hutchison UAMH 6056; Kings Co., Parker Place Ridge, near Delhaven, under Fagus grandifolia, Populus tremuloides and Abies balsamea, 5.ix.86, R.G.Thorn UAMH 5812.

Leccinum

Colonies cottony with little or no pigment diffusing into the agar; hyphae lacking clamp connections; always associated with angiosperms; lipase (+), urease (+,growth absent), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-); tolerant to benomyl, sensitive to cycloheximide; polyphenol oxidase activity (tyrosinase dominant), diazonium blue B reaction on non-treated mycelia (negative).

25. Leccinum arenicola Redhead & Watling

MACROMORPHOLOGY: BAF: slightly irregularly circular, 8-17 mm in diameter, cottony, white, with a raised even margin. Reverse brownish grey (6E2) to dark brown (6F8) in centre surrounded by greyish yellow (4C5) to light orange (6A5), with pale yellow (4A3) at the margin. PDA: irregularly circular, occasionally bayed, 15-21 mm in diameter, cottony, white, with a raised even margin. Reverse yellowish brown (5D6) to greyish brown (6D3) in centre with light yellow (4A4) to pale orange (5A3) at the margin. MN: circular, 19-39 mm in diameter, cottony, sometimes lacunose, white, with a raised even margin. Reverse dark brown

(6F8) under plug, surrounded by light orange (5A5), with pale yellow (4A3) at the margin. Hagem's: circular, 20-44 mm in diameter, cottony, white, sometimes tinged with brownish grey (5E2), with a raised even margin. Reverse yellowish brown (5F8) to dark brown (6F8) in centre surrounded by yellowish brown (5D4) to brown (6E8), with pastel yellow (3A4) to light orange (5A4) at the margin.
MICROMORPHOLOGY: Hyphae (1.3-)1.6-3.2(-3.9) um in diameter, hyaline, lacking clamp connections, when submerged occasionally becoming slightly contorted and twisted.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (+), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-), urease activity (+, growth absent), sensitive at 7°C, tolerant at 30°C, tolerant to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), sensitive to rose bengal (10ug/mL), semi-tolerant to malachite green (2ug/mL), semi-tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (tyrosinase dominant), DBB reaction on non-treated mycelia (negative).
HABITAT: associated with Hudsonia, eastern North America (Redhead and Watling 1979).
ISOLATE EXAMINED: CANADA: NOVA SCOTIA: Kings Co., 5 km E of Kingston, among Hudsonia ericoides, 2.ix.85, L.J.Hutchison UAMH 5927.

26. Leccinum aurantiacum (Bull.) S.F.Gray
MACROMORPHOLOGY: BAF: slightly irregularly circular, 14-16(-29) mm in diameter, cottony to felty, white, agar depressed at a raised even margin. Reverse yellowish brown (5F8) in centre, surrounded by brownish orange (6C8), with yellowish white (3A2) at the margin. PDA: slightly irregularly circular, 16-18 mm in diameter, cottony to felty, very lacunose, often producing droplets of clear liquid on surface, white, agar depressed at a raised ±even margin. Reverse brown (7E7) in centre, surrounded by greyish orange (6B5), with yellowish white (3A2) at the margin. MN: circular, 41-49 mm in diameter, sparsely cottony, white, with a raised even margin. Reverse reddish brown (8E5) in centre surrounded by reddish orange (7B7), with yellowish white (3A2) at the margin. Hagem's: circular to slightly irregularly circular, 27-32 mm in diameter, compact cottony, lacunose, producing droplets of clear liquid on surface, white, with a raised even margin. Reverse reddish brown (8E8) in centre surrounded by brownish orange (7C8) then a band of pale orange (5A3), with yellowish white (3A2) at the margin.
MICROMORPHOLOGY: Hyphae (1.3-)2.0-3.9 um in diameter, hyaline, lacking clamp connections.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (+), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-), urease activity (+, growth absent), sensitive at 7°C, sensitive at 30°C, tolerant to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), semi-tolerant to malachite green (2ug/mL), sensitive to sodium chloride (10mg/mL), polyphenol oxidase activity (tyrosinase dominant/equivalent), DBB reaction on non-treated mycelia (negative).
HABITAT: in both coniferous and deciduous woods under aspens (Populus tremuloides and P. grandidentata) throughout the range of these trees in North America (Snell and Dick 1970; Smith and Thiers 1971; Miller 1980; McKnight and McKnight 1987).

ISOLATE EXAMINED: CANADA: ONTARIO: Timiskaming District, Burt Twp., 2.5 km W of Burt Lake, under Pinus banksiana in plantation, with Populus tremuloides nearby, 23.viii.86, L.J.Hutchison UAMH 5921.
LITERATURE REPORTS OF CULTURAL CHARACTERS: Melin (1923b) as Boletus rufus Schaeff., Nevolin (1963) as Boletus versipelis var. aurantiacus, Besl et al. (1989).

27. Leccinum holopus (Rostk.) Watling
MACROMORPHOLOGY: BAF: circular to irregular, 8-13 mm in diameter, cottony to felty, white to brownish grey (6D2) with light brown (7D4) at an appressed even margin where agar is depressed. Reverse dark brown (7F8) surrounded by brown (7E8) at the margin. Light brown pigment diffusing into the agar around the colony. PDA: circular to irregular, 7-10 mm in diameter, cottony to floccose, whitish, light brown (7D4) at an appressed ±uneven margin where agar is depressed. Reverse dark brown (7F8) with light brown (7D4) at the margin. MN: circular to irregular, 7-11 mm in diameter, cottony to floccose, white, greyish brown (7D3) at an appressed even margin where agar is depressed. Reverse brown (7E5) with greyish brown (7D3) at the margin. Hagem's: circular to irregular, 7-10 mm in diameter, cottony to floccose, white, light brown (7D4) at an appressed even margin where agar is depressed. Reverse dark brown (7F8) surrounded by light brown (7D4) at the margin.
MICROMORPHOLOGY: Hyphae (1.6-)2.0-3.9(-4.5) um wide, hyaline, lacking clamp connections.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-/+), amylse (-/+), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-), urease activity (-/+, growth absent), semi-tolerant at 7°C, tolerant at 30°C, tolerant to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), sensitive to rose bengal (10ug/mL), sensitive to malachite green (2ug/mL), tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (tyrosinase dominant), DBB reaction on non-treated mycelia (negative).
HABITAT: under Betula throughout eastern North America (Snell and Dick 1970; Grund and Harrison 1976; McKnight and McKnight 1987).
ISOLATE EXAMINED: CANADA: NEW BRUNSWICK: Charlotte Co., St. Andrews, in moss under Betula papyrifera and Abies balsamea, 4.ix.85, L.J.Hutchison UAMH 5932.
REMARKS: Many birch-associated Leccinum species exist (e.g. L.scabrum, L.rotundifolia and L.oxydabile) which have not been examined in this present investigation. Therefore possible problems in positive identification of L.holopus isolates from birch mycorrhizae may potentially occur.

PAXILLACEAE

28. Paxillus involutus (Batsch: Fr.) Fr.
MACROMORPHOLOGY: BAF: circular to slightly circular, (21-)31-58 mm in diameter, cottony to floccose to felty, lacunose, light brown (6D5-6D6) to brown (7E8), sometimes zonate with brownish orange (5C3) to reddish brown (8D4) at a raised to appressed even margin where agar is sometimes depressed. Reverse dark brown (6F8-8F8) to black, surrounded often by brownish red (8C8) to violet brown (11E8), with brownish red (8C8) to orange (6A6) at the margin. Brown to dark brown pigment diffusing into the agar sometimes forming opaque halo around the colony. PDA: circular

to irregularly circular, 26-48(-64) mm in diameter, thinly cottony to cottony to floccose to felty, rarely reaching lid of petri dish, sometimes producing dark brown droplets of liquid on surface, dull white to light brown (6D4) to dark brown (7F8), occasionally greyish yellow (4C4) surrounding this, with a raised to appressed even to uneven margin. Reverse reddish brown (8F8) to black in centre surrounded by reddish brown (8D8) to violet brown (10E8). Dark reddish brown to brownish orange pigment diffusing into the agar. MN: circular to irregularly circular, (25-)38-62(-80) mm in diameter, thinly cottony to cottony to felty, sometimes lacunose, mycelium rarely reaching lid of petri dish, occasionally producing brown droplets on surface, whitish to brownish orange (5C3-6C4) through to brown (6E4) sometimes greyish orange (5B3) to dark brown (6F8) at a raised to appressed even to uneven (fimbriate) margin. Reverse dark brown (6F8-9F8) to violet brown (11F8) surrounded by brownish red (8V7) to violet brown (10E8), with orange yellow (4A6) to brownish orange (6C8-7C8) at the margin, radial grooves visible beneath colony when lacunose. Light brownish pigment diffusing into the agar. Hagem's: circular to irregularly circular, (16-)30-61 (-85) mm in diameter, thinly cottony to cottony to felty, sometimes lacunose, mycelium rarely reaching lid of petri dish, occasionally sectoring, greyish orange (5B3) to brown (6E6), with orange white (5A2) to dark brown (6F8) at a raised even to uneven (fimbriate) margin. Reverse greyish brown (5F3) to dark brown (6F8-7F8) through to violet brown (10F8) in centre surrounded by orange (6B7) to brown (6E8), with light yellow (4A5) to orange (6A6) at the margin. Sometimes very light brown pigment diffusing into the agar.

MICROMORPHOLOGY: Hyphae (1.3-)2.0-3.2(-4.5) rarely up to 7.0 um in diameter, hyaline, possessing clamp connections although sometimes pseudoclamps present instead.

PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-), urease activity (-, growth present), sensitive to semi-tolerant at 7°C, sensitive to semi-tolerant at 30°C, tolerant to benomyl (10ug/mL), tolerant to cycloheximide (2ug/mL), variable response to rose bengal (10ug/mL), variable response to malachite green (2ug/mL), semi-tolerant to tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (negative), DBB reaction on non-treated mycelia (negative).

HABITAT: coniferous and deciduous woods throughout North America (Miller 1980; Lincoff 1981; McKnight and McKnight 1987).

ISOLATES EXAMINED: CANADA: NEW BRUNSWICK: Charlotte Co., St. Andrews Twp., St. Andrews, under Picea rubens, 31.viii.86, L.J.Hutchison UAMH 5817; NEWFOUNDLAND: Labrador, 4 km S of Schefferville at Bean Lake, on disturbed earth near Betula glandulosa, 29.viii.84, D.W.Malloch UAMH 6155; ONTARIO: Timiskaming District, Burt Twp., Burt Lake, on rotten wood under Picea glauca and Betula papyrifera, 9.ix.82, R.C.Summerbell UAMH 6156; QUEBEC: Quebec Co., Quebec City, 1980, C.Godbout UAMH 6055.

LITERATURE REPORTS OF CULTURAL CHARACTERS: How (1942), Mikola (1955), Laiho (1970), Kowalski (1974), Pantidou et al. (1983), Besl et al. (1989).

REMARKS: Laiho (1970) pointed out the great morphological variability of his strains in vitro which was also apparent for the isolates in this study. Fries (1985) found that P.involutus was tetrapolar heterothallic and possessed 3 intersterility groups based on matings with monokaryons.

He recognized one group specific to conifers and the other two groups restricted to deciduous hosts, particularly Betula but found no morphological differences in the basidiomata to allow differentiation among these three groups.

Laiho (1970), Grenville *et al.*, (1985b) and Fox (1986) discussed the production of sclerotia *in vitro* and in association with seedlings.

HYGROPHORACEAE

Hygrophorus

Colony morphology variable; hyphae possessing clamp connections; lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (+), urease (-, growth present); tolerant to benomyl, sensitive to sodium chloride; diazonium blue B reaction on non-treated mycelia (yellow).

29. *Hygrophorus eburneus* (Bull.: Fr.) Fr.

MACROMORPHOLOGY: BAF: circular to slightly irregular circular, 39-41 mm in diameter, appressed plumose, lacunose, greyish orange (5B3), hyaline to white at an appressed ± uneven margin, Reverse dark brown (6F8) under plug, surrounded by brown (6E4), rest of colony greyish orange (6B3) with orange white (5A2) at the margin, radial branching grooves visible beneath the colony. PDA: ellipsoidal to slightly irregularly circular, 30-34 mm in diameter, appressed, pale orange (6B3), hyaline towards an even margin. Reverse brown (6E8) under plug, rest of colony greyish orange (5B3) with orange white (5A2) at the margin. MN: circular to slightly irregularly circular, 38-41 mm in diameter, appressed to slightly plumose-like, flocculose in centre greyish orange (5B3) with white in centre, hyaline at an even margin. Reverse dark brown (6F8) under plug, surrounded by greyish red (7B4) then pale red (7A3), with orange white (6A2) at the margin. Hagem's: ellipsoidal to slightly irregularly circular, 32-36 mm in diameter, appressed, lightly flocculose in centre around plug, lightly lacunose, brownish orange (7C4) with reddish grey (7B2) at an even margin. Reverse dark brown (7F8) under plug, surrounded by brownish orange (7C4) with orange white (6A2) at the margin.

MICROMORPHOLOGY: Hyphae (1.3-)2.0-3.9(-4.5) um wide, hyaline, possessing clamp connections.

PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (+), urease activity (-, growth present), sensitive at 7°C, sensitive at 30°C, tolerant to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), sensitive to rose bengal (2ug/mL), sensitive to malachite green (2ug/mL), sensitive to sodium chloride (10mg/mL), polyphenol oxidase activity (equivalent), DBB reaction on non-treated mycelia (yellow).

HABITAT: in coniferous and mixed forests throughout North America (Hesler and Smith 1963; Bird and Grund 1979; Miller 1980; Lincoff 1981; Homola, Czapowskyj and Blum 1985).

ISOLATE EXAMINED: CANADA: ONTARIO: York Co., York Co. Forest, nr. Aurora, in mixed forest of Tsuga canadensis, Populus tremuloides and Quercus rubra, 4.x.87, R.C.Summerbell UAMH 6072.

LITERATURE REPORTS OF CULTURAL CHARACTERS: Mikola (1955) as Limacium eburneum (Fr.) Kummer.

30. Hygrophorus russula (Schaeff.: Fr.) Quél.
MACROMORPHOLOGY: BAF: ellipsoidal to irregularly circular, 28-40 mm in diameter, appressed, flocculose towards margin, lacunose, greyish orange (5B3) an ± uneven white margin. Reverse greyish orange (5B3) with yellowish white (4A2) at the margin, radial grooves visible from beneath the colony. PDA: circular to slightly ellipsoidal, 8 mm in diameter, appressed, flocculose towards centre, yellowish white (4A2) with a submerged even margin. Reverse orange grey (5B2) under plug, yellowish white (4A2) elsewhere. MN: circular, 36-37 mm in diameter, appressed to felty, pale yellow (4A3), with a raised even white margin. Reverse greyish brown (5E3) under plug, orange white (5A2) elsewhere, with yellowish white (4A2) at the margin. Hagem's: ellipsoidal, 27-28 mm in diameter, appressed felty, lacunose, greyish orange (5B3) with white at centre and ± raised ± even margin. Reverse greyish brown (5E3) under plug, greyish orange (5B3) elsewhere, with yellowish white (4A2) at the margin.
MICROMORPHOLOGY: Hyphae (1.6-)2.0-3.2(-3.9) um wide, hyaline, possessing clamp connections, producing globose to ellipsoidal swellings (10-13 x 12-16 um) when grown on BAF and PDA, only a few on MN.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (+), urease activity (-, growth present), sensitive at 7°C, sensitive at 30°C, tolerant to benomyl (10ug/mL), tolerant to cycloheximide (2ug/mL), sensitive to rose bengal (10ug/mL), tolerant to malachite green (2ug/mL), sensitive to sodium chloride (10mg/mL), polyphenol oxidase activity (laccase dominant), DBB reaction on non-treated mycelia (yellow).
HABITAT: under hardwoods in deciduous and mixed woods, eastern North America (Hesler and Smith 1963; Bird and Grund 1979; Miller 1980; Homola, Czapowskyj and Blum 1985; McKnight and McKnight 1987).
ISOLATE EXAMINED: CANADA: ONTARIO: Nipissing District, Algonquin Provincial Park, Canisbay Twp., Pog Lake, under Populus tremuloides and Picea glauca, 10.x.87, R.G.Thorn UAMH 6071.

TRICHOLOMATACEAE

Laccaria

Colonies appressed to floccose; hyphae possessing clamp connections and hyphal coils commonly found; lipase (-), amylase (-), acidification of BCP-casamino acids agar (-), gelatinase (mostly -), degradation of casamino acids (mostly +), urease (+, growth present); mostly semi-tolerant to tolerant at 7°C, tolerant at 30°C; tolerant to benomyl, cycloheximide and rose bengal, semi-tolerant to tolerant to sodium chloride; polyphenol oxidase activity (tyrosinase dominant); diazonium blue B reaction on non-treated mycelia (yellow).

31. Laccaria bicolor (R.Mre.) Orton
MACROMORPHOLOGY: BAF: circular to slightly irregularly circular, (58-)64-78(-85) mm in diameter, flocculose, funiculose around plug, frequently lacunose, deep violet (16D8) to dull violet (16D2) through to purplish white (14A2) to greyish magenta (14D3) in centre, surrounded by greyish violet (16C4) to greyish magenta (14D7), with an appressed uneven hyaline margin. Reverse greyish violet (16D6) to greyish red (8B3) in centre, surrounded by greyish violet (15C4) to greyish magenta

(14D4) with yellowish white (4A2) to hyaline at the margin, agar rarely cracking below the colony. PDA: circular to slightly irregularly circular, usually covering petri plate, appressed, slightly floccose to funiculose towards centre, frequently white but usually pale violet (15A3) to violet grey (17C2) to pinkish white (8A2) in centre, white to pinkish white (7A2) elsewhere, with an uneven margin. Reverse pale red (8A3) to yellowish white (4A2) in centre, greyish violet (15B3) to pinkish white (7A2) elsewhere. MN: circular to slightly irregularly circular, (67-)75-80(-85) mm in diameter, appressed to floccose, woolly around inoculum plug, deep violet (16D8) to greyish violet (16D3-16D4) through to purplish grey (14C2) in centre, surrounded by lilac (16B3) to violet grey (16C2-16D2), with an appressed uneven light grey (D1) to white to hyaline margin. Reverse greyish violet (16C5-16D5) to reddish lilac (14C3) in centre surrounded by greyish violet (16D4) to dull lilac (16C3) with pale grey (B1) to whitish at the margin. Hagem's: ±circular, 37-49(-64) mm in diameter, floccose to woolly, funiculose around plug, frequently lacunose (radially and cerebriform), violet white (18A2) to dull violet (16D3) in centre, surrounded by greyish magenta (13C4) to greyish violet (18B4), with pale grey (B1) to pinkish white (9A2) to hyaline at the appressed to rarely submerged uneven margin. Reverse dull lilac (16C3) to reddish lilac (14C4) in centre, surrounded by greyish lilac (15B2) to greyish magenta (13C3) through to pale orange (6A3), with pinkish white (9A2) to whitish at the margin, with grooves visible beneath the colony when lacunose.

MICROMORPHOLOGY: Hyphae (1.3-)2.0-2.6(-3.2) rarely up to 3.9 um in diameter, hyaline, possessing clamp connections, frequently producing swellings but not always present, globose to ellipsoidal 5.8-13.0 x 7.1-16.9 um, coils commonly produced 20-60 um in diameter.

PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (+), acidification of BCP-casamino acids agar (-), urease activity (+, growth present), semi-tolerant at 7°C, tolerant at 30°C, semi-tolerant to tolerant to benomyl (10ug/mL), tolerant to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), variable response to malachite green (2ug/mL), tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (tyrosinase dominant; rarely equivalent), DBB reaction on non-treated mycelia (yellow).

HABITAT: in coniferous forests throughout North America (Lahaie 1981; Mueller 1982)

ISOLATES EXAMINED: CANADA: ALBERTA: Slave Lake Forest, under *Pinus contorta* and *Picea glauca*, 4.ix.85, R.S.Currah UAMH 5268; Rocky-Clearwater Forest, under *Pinus contorta*, 13.viii.86, R.S.Currah UAMH 5476; ONTARIO: Timiskaming District, Burt Twp., Burt Lake, on rotting logs and humus under *Picea glauca*, *Abies balsamea* and *Betula* sp., 25.viii.79, D.G.Lahaie UAMH 6150; on moss covered rotten log under *Picea mariana*, *Abies balsamea*, *Populus tremuloides* and *Betula papyrifera*, 7.viii.79, D.G.Lahaie UAMH 6151; under *Alnus rugosa* and *Picea mariana*, 1981, J.-A.Fortin UAMH 6152; on bare ground near *Picea glauca*, 3.vi.82, R.C.Summerbell UAMH 6061; in debris and humus of cutover *Pinus banksiana*-*Picea mariana* forest, 23.viii.79, D.G.Lahaie UAMH 6153.

LITERATURE REPORTS OF CULTURAL CHARACTERS: Lahaie (1981), Mueller (1982).

REMARKS: *Laccaria bicolor* occurs within the '*Laccaria laccata* complex' and can be distinguished *in vitro* from *L.laccata* by its violet coloured versus white colonies on most agar media (Mueller 1982). Lahaie (1981) reported *L.bicolor* as *L.laccata* type I which differed from *L.laccata* type II (the true *L.laccata*) by the violet versus white colonies. Agerer (1988) suggested that the colours of mycorrhizae were a reflection of the colours of the stipes of basidiomata. Likewise, this could apply to colonies as well since *L.bicolor* has violet mycelia at the base of the stipe of basidiomata while *L.laccata* does not (Mueller 1982).

Fries and Mueller (1984) and later Kropp and Fortin (1988) showed that *L.bicolor* was tetrapolar heterothallic. Fries and Mueller also showed that *L.bicolor* was intersterile with other species within the *L.laccata* complex.

32. *Laccaria laccata* (Scop.: Fr.) Berk. & Br.

MACROMORPHOLOGY: BAF: ±circular to slightly irregularly circular, 53-64 mm in diameter, appressed, somewhat slimy-looking, flocculose to funiculose towards centre, white, hyaline at the uneven margin. Reverse yellowish white (3A2). PDA: ±circular to slightly irregularly circular, 70-75 mm in diameter, appressed and somewhat slimy-looking, sometimes funiculose around inoculum plug, white, hyaline at the uneven margin. Reverse yellowish white (3A2). MN: circular to slightly irregularly circular, 59-63 mm in diameter, appressed and somewhat slimy-looking, floccose towards centre, white with a touch of pinkish white (7A2) at centre, sometimes with a touch of violet white (15A2) in centre when younger, with an uneven hyaline margin. Reverse dull white to orange white (5A2). Hagem's: ±circular to slightly irregularly circular, 34-38 mm in diameter, appressed and somewhat slimy-looking, sometimes slightly lacunose, floccose to funiculose around inoculum plug, whitish with a tinge of pinkish white (13A2) towards centre with an uneven margin. Reverse whitish.
MICROMORPHOLOGY: Hyphae (1.0-)2.0-3.2(-3.6) um in diameter, hyaline, possessing clamp connections, sometimes producing globose to ellipsoidal swellings particularly on BAF agar 7.8-12.0 x 8.5-16.2 um.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-/+), degradation of casamino acids (-/+), acidification of BCP-casamino acids agar (-), urease activity (+, growth present), semi-tolerant at 7°C, tolerant at 30°C, tolerant to benomyl (10ug/mL), tolerant to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), semi-tolerant to malachite green (2ug/mL), semi-tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (tyrosinase dominant), DBB reaction on non-treated mycelia (yellow).
HABITAT: deciduous and coniferous woods throughout North America, often in disturbed sites (Miller 1980; Lahaie 1981; Lincoff 1981; Mueller 1982; McKnight and McKnight 1987).
ISOLATE EXAMINED: JAPAN: 1973, T.Yokoyama UAMH 6063.
LITERATURE REPORTS OF CULTURAL CHARACTERS: Mikola (1955), Lahaie (1981), Mueller (1982).
REMARKS: As previously mentioned under *L.bicolor*, *L.laccata* possesses white colonies *in vitro* and this differentiates it from most other members of the genus (Mueller 1982). Fries and Mueller (1984) showed that it possessed a tetrapolar heterothallic mating system.

The culture reported as *L.laccata* by Pantidou *et al*. (1983) was re-examined by Hutchison (1989) and found to be a species of *Pleurotus*.

33. Laccaria ochropurpurea (Berk.) Peck
MACROMORPHOLOGY: BAF: circular, 11-13 mm in diameter, appressed, floccose to woolly on plug, hyaline but greyish violet (17B4) at inoculum plug, with an even margin. Reverse dull violet (16E4) in centre, white elsewhere. PDA: circular, 15-18 mm in diameter, appressed to floccose, floccose on plug, red (9A7) to reddish lilac (14C4) in centre, with a whitish to hyaline even margin. Reverse dark violet (16F3) surrounded by pastel red (7A4) to reddish brown (9D5), with hyaline to whitish at the margin. MN: circular, 19-22 mm in diameter, slightly floccose in centre, appressed elsewhere, violet white (16A2) on plug, greyish magenta (14D5) elsewhere and with an even hyaline margin. Reverse dark purple (14F3) under plug, surrounded by reddish lilac (14C3) with white at the margin. Hagem's: circular, 17-18 mm in diameter, appressed to slightly floccose, floccose to cottony on plug, violet grey (15C2), with a hyaline even margin. Reverse dark violet (16F4) in centre, surrounded by hyaline to white at the margin.
MICROMORPHOLOGY: Hyphae (1.6-)2.0-2.6 rarely reaching 3.2 um in diameter, hyaline, possessing clamp connections.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-), urease activity (+, growth present), sensitive at 7°C, tolerant at 30°C, semi-tolerant to benomyl (10ug/mL), tolerant to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), sensitive to malachite green (2ug/mL), semi-tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (tyrosinase dominant), DBB reaction on non-treated mycelia (yellow).
HABITAT: in deciduous and mixed woods under Quercus, eastern North America (Lahaie 1981; Lincoff 1981).
ISOLATE EXAMINED: CANADA: ONTARIO: Peel Co., Mississauga, under Quercus macrocarpa and Quercus rubra, 22.vii.84, D.W.Malloch UAMH 5814.
LITERATURE REPORTS OF CULTURAL CHARACTERS: Mueller (1982).

34. Laccaria proxima (Boud.) Pat.
MACROMORPHOLOGY: BAF: circular to slightly irregularly circular, 78-82 mm in diameter, appressed, hyaline to white with deep violet (16E8) at plug, over longer periods of time producing tufts of deep violet (16D8) to purplish grey (14C2) over surface, with an uneven margin. Reverse dull violet (16E4) under plug, elsewhere hyaline to whitish. PDA: circular to slightly irregularly circular, 76-82 mm in diameter, appressed to flocculose often slimy-looking, white, hyaline at the appressed uneven margin, over time producing tufts of deep violet (16D8) to purplish grey (14C2) over surface but not as well developed as on BAF agar. Reverse hyaline to whitish. MN: circular to slightly irregularly circular, usually covering petri plate, appressed, occasionally floccose to funiculose, hyaline to white, with an uneven margin. Reverse dull whitish to hyaline. Hagem's: circular to slightly irregularly circular, 65-73 mm in diameter, floccose to funiculose, white, with an appressed uneven hyaline margin. Reverse white to yellowish white (3A2).
MICROMORPHOLOGY: Hyphae (1.3-)2.0-2.6(-3.2) rarely up to 3.9 um wide, hyaline, clamp connections present; coils commonly produced, 20-50 um in diameter.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (+), acidification of BCP-casamino acids agar (-), urease activity (+, growth present), tolerant

at 7°C, tolerant at 30°C, tolerant to benomyl (10ug/mL), tolerant to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), semi-tolerant to malachite green (2ug/mL), tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (tyrosinase dominant), DBB reaction on non-treated mycelia (yellow).
HABITAT: disturbed sites in both coniferous and deciduous forests throughout North America (Lahaie 1981; Mueller 1982).
ISOLATE EXAMINED: JAPAN: 1977, T.Yokoyama UAMH 6062.
LITERATURE REPORTS OF CULTURAL CHARACTERS: Kowalski (1974), Lahaie (1981), Mueller (1982).
REMARKS: _Laccaria_ _proxima_ is a member of the _L.laccata_ complex. Although it possesses white colonies, violet tufts appear after 5 weeks on BAF and PDA differentiating it from _L.laccata_.

Fries and Mueller (1984) reported that _L.proxima_ was tetrapolar heterothallic and was intersterile with _L.laccata_.

Tricholoma

Colonies mostly cottony; hyphae lacking clamp connections, or if present very rare; lipase (mostly -), gelatinase (mostly -), acidification of BCP-casamino acids agar (-, except _T.myomyces_); sensitive to semi-tolerant to benomyl, semi-tolerant to tolerant to malachite green, mostly sensitive to sodium chloride (except _T.cingulatum_); polyphenol oxidase activity [subgenus Tricholoma section Tricholoma (laccase dominant), subgenus Tricholoma section Genuina (negative to weakly laccase dominant)]; diazonium blue B reaction on non-treated mycelia (mostly yellow).

35. _Tricholoma_ _albobrunneum_ (Pers.: Fr.) Staude
MACROMORPHOLOGY: BAF: circular to slightly irregularly circular, 42-47 mm in diameter, cottony, lacunose, white, with a raised even margin. Reverse brownish orange (6C3) in centre, surrounded by mottling of greyish orange (6B3) and orange white (5A2), with yellowish white (4A2) at the margin, with cracking of the agar occurring below the colony. PDA: irregularly circular, 47-52 mm in diameter, cottony-felty, white, with a raised to submerged uneven margin. Reverse with mottling of brown (6E4) and greyish orange (6B4), with pale yellow at the margin. MN: circular, 67-73 mm in diameter, cottony, white, with a raised uneven margin. Reverse greyish red (8C4) under plug surrounded by greyish orange (6B4), with yellowish white (4A2) at the margin. Hagem's: ±circular, 50-59 mm in diameter, cottony, white, with a raised even margin. Reverse brownish orange (5C4) surrounded by orange white (5A2) with yellowish white (4A2) at the margin.
MICROMORPHOLOGY: Hyphae (1.6-)2.0-3.2(-3.9) um in diameter, hyaline, lacking clamp connections.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-/+), degradation of casamino acids (+), acidification of BCP-casamino acids agar (-), urease activity (-, growth present), sensitive at 7°C, sensitive at 30°C, semi-tolerant to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), sensitive to rose bengal (10ug/mL), tolerant to malachite green (2ug/mL), sensitive to sodium chloride (10mg/mL), polyphenol oxidase activity (negative), DBB reaction on non-treated mycelia (yellow).
HABITAT: under conifers, particularly _Pinus_ (Malloch 1974; Pomerleau 1980).

ISOLATE EXAMINED: CANADA: ONTARIO: Nipissing District, Algonquin Provincial Park, Canisbay Twp., in *Polytrichum* moss under *Picea glauca*, *Pinus strobus* and *Populus tremuloides*, 3.x.87, L.J.Hutchison UAMH 6068.
LITERATURE REPORTS OF CULTURAL CHARACTERS: Modess (1941), Semerdzieva (1965).

36. *Tricholoma aurantium* (Schaeff.: Fr.) Ricken
MACROMORPHOLOGY: BAF: circular to slightly irregularly circular, 18-21 mm in diameter, felty-cottony, lacunose, yellowish brown (5D5) in centre, white elsewhere, with a raised even hyaline margin where the agar is slightly depressed. Reverse yellowish brown (5F8) in centre with greyish orange (5B5) surrounding this and yellowish white (4A2) at the margin. PDA: slightly irregularly circular, 19-21 mm in diameter, felty-cottony, lacunose, brown (6E8) in centre, surrounded by pale yellow (5A3), with brownish grey (4E2) elsewhere, with a submerged ±even hyaline margin. Reverse reddish brown (8E8) surrounded by ring of orange (6B7) with pale yellow (4A3) at the margin, with agar cracking below centre of the colony. MN: slightly irregularly circular to irregularly circular, 14-20 mm in diameter, sparsely cottony to cottony, white, with a submerged to raised ±uneven margin. Reverse dark brown (7F8) in centre surrounded by pale orange (5A3) at the margin. Slight pigment diffusing into the agar. Hagem's: circular to slightly irregularly circular, 17-25 mm in diameter, cottony, concentrically lacunose, white to yellowish white (4A2), with a raised ±uneven margin. Reverse dark brown (7F8) in centre, surrounded by yellowish white (4A2) at the margin.
MICROMORPHOLOGY: Hyphae (1.3-)2.0-3.2(-3.6) um in diameter, hyaline, lacking clamp connections.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-/+), acidification of BCP-casamino acids agar (-), urease activity (-, growth present), sensitive at 7°C, sensitive at 30°C, sensitive to benomyl (10ug/mL), semi-tolerant to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), tolerant to malachite green (2ug/mL), semi-tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (laccase dominant), DBB reaction on non-treated mycelia (yellow).
HABITAT: under conifers in coniferous and mixed forests throughout North America (Miller 1980; Ovrebo 1980; Lincoff 1981; McKnight and McKnight 1987).
ISOLATE EXAMINED: CANADA: ALBERTA: Rocky-Clearwater Forest, under *Picea glauca* and *Populus* sp., 6.viii.86, R.S.Currah UAMH 5497.
LITERATURE REPORTS OF CULTURAL CHARACTERS: Pantidou *et al*. (1983).

37. *Tricholoma cingulatum* (Ahmfelt) Jacobasch
MACROMORPHOLOGY: BAF: ±circular, 32-34 mm in diameter, cottony to appressed cottony, lacunose, white, with an appressed to raised even margin. Reverse greyish orange (5B4) in centre surrounded by pale yellow (4A3) at the margin, with radial grooves visible below the colony. PDA: circular, 28-29 mm in diameter, cottony to appressed cottony, white, with an appressed to raised even margin. Reverse greyish red (9B5) under plug, surrounded by pale orange (5A3), with pale yellow (4A3) at the margin. MN: circular, 42-44 mm in diameter, cottony to appressed cottony, lacunose in centre, white, with an appressed to raised even margin. Reverse pale orange (5A3) in centre with orange

white (5A2) at the margin, with radial grooves visible below the colony. Hagem's: circular, 32-33 mm in diameter, cottony, white, with a raised ±even margin. Reverse greyish yellow (4B4) in centre with pale yellow (4A3) at the margin.

MICROMORPHOLOGY: Hyphae 1.3-2.6(-3.2) um in diameter, hyaline, lacking clamp connections.

PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (+), acidification of BCP-casamino acids agar (-), urease activity (+, growth absent/present), semi-tolerant at 7°C, sensitive at 30°C, semi-tolerant to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), tolerant to malachite green (2ug/mL), tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (laccase dominant), DBB reaction on non-treated mycelia (yellow).

HABITAT: under *Salix* throughout North America (Ovrebo 1989).

ISOLATE EXAMINED: CANADA: QUEBEC: Portneuf Co., St. Augustin, under *Salix* spp., *Populus tremuloides*, and *Pinus resinosa*, 1981, C.Godbout CRBF 112.

38. *Tricholoma focale* (Fr.) Ricken [syn. *T.zelleri* (Stuntz & A.H.Smith) Ovrebo & Tylutki]

MACROMORPHOLOGY: BAF: circular but sectoring along entire length of margin, 52-58 mm in diameter, cottony, becoming felty towards centre, often lacunose, yellowish white (4A2), light brown (6D4) on sectored portions, with a raised even margin. Reverse dark brown (7F8) surrounded by brown (7E6) with greyish orange (5B4) at the margin. PDA: circular to slightly irregularly circular, 35-40 mm in diameter, sparsely cottony to felty, greyish orange (5B4) with a raised even light grey (C1) margin. Reverse dark ruby (12F8) to black in centre, surrounded by violet brown (11E8), with greyish red (8B5) at the margin. Orange brown pigment diffusing into the agar. MN: circular to slightly irregularly circular, 48-51 mm in diameter, cottony, orange white (5A2) in centre, with yellowish white (4A2) towards a raised even margin. Reverse dark brown (6F8) in centre surrounded by band of light orange (5A4), with yellowish white (4A2) at the margin. Hagem's: circular to slightly irregularly circular, 37-44 mm in diameter, cottony, white, with a raised even margin. Reverse olive brown (4F6) in centre surrounded by greyish orange (6B6) with yellowish white (4A2) at the margin.

MICROMORPHOLOGY: Hyphae 1.6-3.2 rarely up to 3.9 um in diameter, hyaline, lacking clamp connections.

PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (+), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-), urease activity (-, growth present), sensitive at 7°C, sensitive at 30°C, sensitive to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), sensitive to rose bengal (10ug/mL), tolerant to malachite green (2ug/mL), sensitive to sodium chloride (10mg/mL), polyphenol oxidase activity (negative), DBB reaction on non-treated mycelia (yellow).

HABITAT: in northern coniferous forests under *Pinus* throughout North America but particularly in the northwest of USA and adjacent Canada (Miller 1980; Ovrebo 1980; Lincoff 1981).

ISOLATE EXAMINED: CANADA: ONTARIO: York Co., York Regional Forest-Porrit Tract, nr Ballantrae, in *Pleurozium* moss under *Pinus banksiana* and *Pinus*

sylvestris, 15.x.87, L.J.Hutchison UAMH 6069.
REMARKS: Because of the brown pigments diffusing into the agar (BAF and PDA) in fresh isolates, cultures of T.focale may be confused with cultures of boletes and their gasteroid counterparts. However, its sensitivity to benomyl differentiates it.

39. Tricholoma fulvum (DC.: Fr.) Sacc. [syn. Tricholoma flavobrunneum (Fr.) Kummer]
MACROMORPHOLOGY: BAF: irregularly circular, 12-18 mm in diameter, cottony, becoming felty in centre, sometimes colony sectoring, often lacunose, dark brown (6F8) to brown (6E8) in centre, with a raised even to uneven white margin where agar is depressed. Reverse dark brown (6F8) in centre surrounded by greyish brown (6E3) to dark brown (6F5), with light orange (5A4-5A5) at the margin, with slight cracking of agar below the colony when lacunose. Light brown pigment diffusing into the agar. PDA: irregularly circular, 18-26 mm in diameter, cottony, becoming felty in centre, often lacunose, often producing honey-coloured droplets on surface, dark brown (6F8) to brown (6E8) in centre, surrounded by light brown (6D6) to light grey (C1), with pale yellow (4A3) to white at a raised even to uneven margin where agar is sometimes depressed. Reverse dark brown (6F4-6F8) in centre with light yellow (4A4) to light orange (5A4) at the margin, with agar cracking below the colony when lacunose. Slight brown pigment diffusing into the agar. MN: irregularly circular, (14-)18-24(-30) mm in diameter, cottony, becoming felty at centre, often lacunose, yellowish brown (5D5) to brown (6E7) in centre around plug, white to yellowish white (4A2) elsewhere, with a raised even to uneven margin. Reverse dark brown (6F5-6F8) in centre surrounded by greyish brown (6F3), with light yellow (4A2) to orange white (5A2) at the margin, with some cracking of agar below the colony when lacunose. Occasionally slight pigment diffusing into the agar. Hagem's: circular to very irregular, 17-25(-29) mm in diameter, cottony, often lacunose, brown (6E8-7E8) to dark brown (6F8) in centre of colony surrounded by greyish brown (6D3) to reddish grey (7B2) with white at the raised even to uneven margin where agar is sometimes depressed. Reverse dark brown (6F8-7F8) to brown (7E4) in centre, surrounded by brownish grey (7E2) to greyish brown (6F3-7F3), with greyish orange (6B3) to orange white (5A2) to white at the margin, with cracking of agar below the colony when lacunose.
MICROMORPHOLOGY: Hyphae (1.6-)2.0-4.5(-5.2) um in diameter, hyaline, slightly pigmented in centre of colony, lacking clamp connections, rarely producing globose to ellipsoidal swellings 6.5-15.6 x 9.8-21.0 um.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (+), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-), urease activity (-, growth present; sometimes +, growth absent), sensitive at 7°C, sensitive at 30°C, sensitive to semi-tolerant to benomyl (10ug/mL), semi-tolerant to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), semi-tolerant to tolerant to malachite green (2ug/mL), sensitive to sodium chloride (10mg/mL), polyphenol oxidase activity (laccase dominant), DBB reaction on non-treated mycelia (yellow).
HABITAT: coniferous, deciduous and mixed woods under Betula, throughout North America (Malloch 1974; Ovrebo 1980; Pomerleau 1980).

ISOLATES EXAMINED: CANADA: ONTARIO: Timiskaming District, Burt Twp., Burt Lake, under Betula papyrifera and Abies balsamea, 3.ix.81, D.W.Malloch UAMH 5939, 6205, 6206.
LITERATURE REPORTS OF CULTURAL CHARACTERS: Melin (1923b).
REMARKS: T.fulvum exudes brown pigments into the agar (BAF & PDA) over time, and thus could be confused with members of the Boletaceae and their gasteroid relatives. However, its sensitivity to benomyl easily distinguishes it.

40. **Tricholoma imbricatum** (Fr.: Fr.) Kummer

MACROMORPHOLOGY: BAF: ± circular, 28-31 mm in diameter, felty-cottony, lacunose, greyish yellow (4B3) in centre, with a raised even white margin. Reverse yellowish brown (5F6) in centre with light yellow (4A4) at the margin, with agar cracking slightly beneath the colonies. PDA: irregularly circular, 15-18 mm in diameter, felty, pale grey (B1) mottled with dark grey (F1) in centre, with a brownish orange (6C8) submerged even margin. Reverse dark brown (6F8) with orange (6B8) at the margin. Slight orange pigment diffusing into the agar. MN: circular, 35-41 mm in diameter, felty-cottony, pale grey (B1) to brownish grey (6C2), with a raised ±even margin. Reverse dark brown (6F8) with yellowish white (4A2) at the margin. Hagem's: circular to slightly irregularly circular, 34-39 mm in diameter, felty-cottony, lacunose, whitish in centre, pale grey (B1) mottled with brownish grey (6C2) at the raised even margin. Reverse dark brown (6F8) in centre, with greyish orange (6B6) at the margin.
MICROMORPHOLOGY: Hyphae (1.3-)2.0-3.2(-3.9) rarely up to 6.1 um in diameter, hyaline, lacking clamp connections.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-), urease activity (-, growth present/absent), sensitive at 7°C, sensitive at 30°C, semi-tolerant to benomyl (10ug/mL), semi-tolerant to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), tolerant to malachite green (2ug/mL), sensitive to sodium chloride (10mg/mL), polyphenol oxidase activity (negative), DBB reaction on non-treated mycelia (yellow).
HABITAT: under Pinus or Picea in northern coniferous forests (Ovrebo and Smith 1979; Ovrebo 1980; Lincoff 1981; McKnight and McKnight 1987).
ISOLATE EXAMINED: CANADA: ALBERTA: Rocky-Clearwater Forest, in mixed Picea woods, 28.vii.86, R.S.Currah UAMH 5501.
LITERATURE REPORTS OF CULTURAL CHARACTERS: Modess (1941).
REMARKS: T.imbricatum is so closely related to T.vaccinum that it is frequently difficult to differentiate basidiomata of the two (Ovrebo and Smith 1979). Their cultures too are almost identical. However, T.imbricatum possesses colonies which have a darker colour and which exude a light brown pigment into the agar (BAF and PDA) when the isolates are fresh. This pigment in the agar was recorded by Modess (1941) on Hagem's agar. T.imbricatum does not have clamp connections in vitro while T.vaccinum occasionally possesses them.

41. **Tricholoma myomyces** (Pers.: Fr.) Lange

MACROMORPHOLOGY: BAF: circular to slightly ellipsoidal, 27-40(-60) mm in diameter, cottony to floccose to felty, white, sometimes with a tinge of yellowish white (4A2) to pale green (30A3) in centre, with an appressed to raised even hyaline margin. Reverse dark brown (7F8) under plug, surrounded by greyish orange (6B6) to brown (6D8), with yellowish white (4A2) to pale orange (5A3) at the margin. PDA: circular to slightly irregularly circular, 16-27 mm in diameter, floccose to flocculose-felty to velvety-cottony, white, sometimes with a tinge of pastel green (30A4) in centre, with an appressed to raised even margin. Reverse light brown (6D6) to brown (6E5-6E8) in centre, surrounded by greyish orange (6B4) to yellowish brown (5D5), with pale yellow (4A3) to yellowish white (4A2) at the margin. MN: circular to slightly ellipsoidal, (30-)44-50 mm in diameter, felty to flocculose to cottony, white, yellowish white (4A2) to brownish orange (7C4) in centre, with an appressed to raised even hyaline margin. Reverse reddish brown (8F8) under plug, surrounded by brownish orange (6C5-7C4) to light brown (7D6), with yellowish white (4A2) to pale yellow (4A3) at the margin. Hagem's: circular to slightly irregularly circular, 27-37 mm in diameter, felty to flocculose to cottony, white, sometimes yellowish white (4A2) in centre, with an appressed to raised even margin. Reverse light brown (6D6) to dark brown (6F8) under plug, rest of colony pale orange (5A3) to brownish orange (6C4) to greyish brown (5D3), with yellowish white (4A2) at the margin.

MICROMORPHOLOGY: Hyphae (1.3-)1.6-2.6(-3.2) um in diameter, hyaline, lacking clamp connections, producing a few intercalary swellings when grown on MN agar, globose to ellipsoidal, 5.8-9.1 x 5.8-16.0 um.

PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (+), urease activity (-/+, growth present), sensitive to semi-tolerant at 7°C, sensitive to semi-tolerant at 30°C, semi-tolerant to tolerant to benomyl (10ug/mL), semi-tolerant to tolerant to cycloheximide (2ug/mL), sensitive to semi-tolerant to rose bengal (10ug/mL), semi-tolerant to tolerant to malachite green (2ug/mL), sensitive to semi-tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (laccase dominant), DBB reaction on non-treated mycelia (negative).

HABITAT: in coniferous and mixed woods under *Pinus* and *Picea* throughout North America (Ovrebo 1989).

ISOLATES EXAMINED: CANADA: ONTARIO: Halton Co., Esquesing Twp., 8 km NW of Milton at Oakville Creek, under *Pinus strobus*, 3.xi.85, D.W.Malloch UAMH 5936; Norfolk Co., Delhi Twp., nr Normandale Fish Hatchery, under *Pinus resinosa* and *Quercus velutina*, 12.x.87, L.J.Hutchison UAMH 6067.

42. *Tricholoma pessundatum* (Fr.: Fr.) Quél.

MACROMORPHOLOGY: BAF: circular to slightly irregularly circular, 28-39(-46) mm in diameter, cottony to appressed cottony, sometimes lacunose, white, with a raised even margin. Reverse mottling of pale yellow (4A3) to brownish orange (6C7) with greyish yellow (4B3) to reddish brown (8E8), yellowish white (4A2) to pale yellow (4A3) at the margin, with radial cracking of agar below the colony when lacunose. PDA: circular, 31-39 mm in diameter, cottony to appressed cottony, white, with a raised to appressed even margin. Reverse dark brown (6F6) in centre surrounded by reddish brown (8E8) with pale yellow (4A3) to light orange (6A5) at the margin. MN: circular, 40-54(-72) mm in diameter, cottony, touching lid of petri dish, white, with a raised even margin. Reverse dark brown (6F8) under plug, surrounded by orange white (6A2) to greyish orange (5B4), with yellowish white (4A2) to pale yellow (4A3) at the margin. Hagem's: circular, (34-)46-71 mm in diameter,

cottony, touching lid of petri dish, white, with a raised even margin. Reverse brownish orange (7C5) under plug, surrounded by orange white (6A2) to greyish orange (5B5), with pale yellow (4A3) to orange white (5A2) at the margin.
MICROMORPHOLOGY: Hyphae (1.3-)2.0-3.2(-3.9) rarely up to 4.6 um in diameter, hyaline, lacking clamp connections.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (+), acidification of BCP-casamino acids agar (-), urease activity (-/+, growth present), sensitive at 7°C, semi-tolerant to tolerant at 30°C, sensitive to semi-tolerant to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), variable response to rose bengal (10ug/mL), semi-tolerant to tolerant to malachite green (2ug/mL), sensitive to sodium chloride (10mg/mL), polyphenol oxidase activity (negative, rarely laccase dominant), DBB reaction on non-treated mycelia (yellow).
HABITAT: under conifers in coniferous and mixed forests throughout North America (Malloch 1974, Ovrebo 1980; Lincoff 1981).
ISOLATES EXAMINED: CANADA: ALBERTA: 150 km N of Fort McMurray, under Pinus banksiana, 1978, R.M.Danielson UAMH 6207; ONTARIO: York Co., York Co. Regional Forest, nr. Ballantrae, in Polytrichum moss under Pinus banksiana, 11.x.87, L.J.Hutchison UAMH 6066.
LITERATURE REPORTS OF CULTURAL CHARACTERS: Modess (1941), Danielson (1984).

43. Tricholoma populinum Lange

MACROMORPHOLOGY: BAF: irregularly circular, 39-47 mm in diameter, cottony, slightly lacunose, white, with a raised to appressed ±even margin. Reverse brown (7E8) in centre, surrounded by greyish orange (6B4) with yellowish white (4A2) at the margin, with radial grooves visible from beneath the colony, with agar slightly cracking beneath centre of the colony. PDA: circular, 44-48 mm in diameter, cottony, greyish beige (4C2) in centre, white elsewhere, with a raised to appressed even margin. Reverse brown (6E8) in centre, surrounded by light brown (6D6) with pale yellow (4A3) at the margin. MN: circular, 45-53 mm in diameter, cottony, often touching lid of petri dish, lacunose in centre, white, with a raised even margin. Reverse brownish orange (6C6) under plug, surrounded by greyish orange (6B5) with yellowish white (4A2) at the margin, with radial grooves visible from beneath the colony, with agar slightly cracking under centre of the colony. Hagem's: slightly irregularly circular, 34-37 mm in diameter, cottony, becoming velvety, lacunose, white, with a raised ±even margin. Reverse brownish orange (6C6) in centre, surrounded by greyish orange (6B5) with pale yellow (4A3) at margin, with radial grooves visible beneath the colony.
MICROMORPHOLOGY: Hyphae (1.3-)2.0-3.2(-3.9) um in diameter, hyaline, lacking clamp connections.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-), urease activity (-/+, growth present), sensitive at 7°C, sensitive at 30°C, semi-tolerant to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), sensitive to rose bengal (10ug/mL), tolerant to malachite green (2ug/mL), sensitive to sodium chloride (10mg/mL), polyphenol oxidase activity (negative), DBB reaction on non-treated mycelia (yellow).

HABITAT: under *Populus* in deciduous and mixed woods throughout North America (Malloch 1974; Lincoff 1981; Turner *et al*. 1987).
ISOLATE EXAMINED: CANADA: QUEBEC: Québec Co., Cap Rouge, under *Populus tremuloides*, 1980, C.Godbout CRBF 91.

44. *Tricholoma resplendens* (Fr.) Karst.
MACROMORPHOLOGY: BAF: circular to slightly irregularly circular, 13-15 mm in diameter, felty, white, with an appressed even hyaline margin. Reverse yellowish brown (5E8-5F8) under plug, rest of colony brownish orange (6C6) with yellowish white (4A2) at the margin. PDA: circular to slightly irregularly circular, 11-13 mm in diameter, felty, pale grey (B1) towards centre, white elsewhere, with an appressed even hyaline margin. Reverse brown (6E6) in centre with orange white (6A2) at the margin. MN: slightly irregular, 20-23 mm in diameter, felty, white, with an appressed even hyaline margin. Reverse greyish orange (6B6) with yellowish white (4A2) at the margin. Hagem's: slightly irregularly circular, 19-21 mm in diameter, felty, lacunose, white, with an appressed even hyaline margin. Reverse greyish orange (6B6) in centre with yellowish white (4A2) at the margin.
MICROMORPHOLOGY: Hyphae 1.6-2.6(-3.0) um in diameter, hyaline, lacking clamp connections.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (+), amylase (+), gelatinase (+), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-), urease activity (+, growth absent), sensitive at 7°C, tolerant at 30°C, sensitive to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), tolerant to malachite green (2ug/mL), sensitive to sodium chloride (10mg/mL), polyphenol oxidase activity (laccase dominant), DBB reaction on non-treated mycelia (negative).
HABITAT: in deciduous and mixed woods in eastern deciduous forest zone, eastern North America (Miller 1980; Ovrebo 1980; McKnight and McKnight 1987)
ISOLATE EXAMINED: CANADA: ONTARIO: Muskoka District, Dorset, under *Quercus rubra* and *Pinus strobus*, 20.ix.86, L.J.Hutchison UAMH 5799.

45. *Tricholoma vaccinum* (Schaeff.: Fr.) Staude
MACROMORPHOLOGY: BAF: circular to slightly irregularly circular, 19-32 mm in diameter, cottony to felty, lacunose, white with greyish yellow (4B3) to light orange (6A4) in centre, with a raised even margin where agar is rarely depressed. Reverse brownish grey (6F2) to yellowish brown (5F8) in centre surrounded by light orange (5A4) to brown (7E7), with yellowish white (3A2-4A2) to pale yellow (4A3) at the margin, with agar cracking slightly beneath the colony. PDA: circular to slightly irregularly circular, 18-28(-35) mm in diameter, cottony, rarely lacunose, white, with greyish yellow (4B4) to yellowish brown (5D5) in centre, with a raised (rarely appressed) even margin. Reverse dark brown (6F8) in centre surrounded by light yellow (4A4) to greyish orange (5B5), with yellowish white (3A2-4A2) at the margin, with agar cracking below the colony when lacunose. MN: circular to slightly irregularly circular, 40-57 mm in diameter, cottony, white with greyish orange (6B5) to brown (6E8) in centre, with a raised even margin. Reverse brown (6E5) to dark brown (6F8-8F8) in centre surrounded by pale orange (5A3), with yellowish white (3A2-4A2) to pale yellow (4A3) at the margin. Hagem's: circular to slightly irregularly circular, 29-48 mm in

diameter, cottony, rarely lacunose, white with yellowish grey (4B2) to brownish orange (5C5) in centre, with a raised even margin. Reverse dark brown (6F8) in centre surrounded by pale orange (5A3) to light brown (6D4), with yellowish white (3A2) to pale yellow (4A3) at the margin, with agar cracking below the colony when lacunose.

MICROMORPHOLOGY: Hyphae (1.3-)1.6-3.2(-3.9) rarely up to 5.2 um in diameter, hyaline, lacking clamp connections but occasionally may be present in some strains.

PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-/+), acidification of BCP-casamino acids agar (-), urease activity (-, growth present), sensitive at 7°C, sensitive at 30°C, sensitive to semi-tolerant to benomyl (10ug/mL), semi-tolerant to cycloheximide (2ug/mL), variable response to rose bengal (10ug/mL), variable response to malachite green (2ug/mL), sensitive to sodium chloride (10mg/mL), polyphenol oxidase activity (negative), DBB reaction on non-treated mycelia (yellow).

HABITAT: in northern coniferous woods under *Pinus* and *Picea* (Ovrebo and Smith 1979; Miller 1980; Ovrebo 1980; Lincoff 1981; McKnight and McKnight 1987).

ISOLATES EXAMINED: CANADA: ALBERTA: Rocky-Clearwater Forest, in woods consisting of *Picea mariana*, *P.glauca*, *Populus* and *Pinus contorta*, 13.viii.86, R.S.Currah UAMH 5502; QUEBEC: Nouveau Québec Territory, 1 km E of Schefferville airport, in *Pleurozium* carpet under *Picea glauca*, *Alnus rugosa*, *Betula glandulosa* and *Salix* sp., 31.viii.84, D.W.Malloch UAMH 6070; 5.7 km NW of Schefferville, in *Cladonia* carpet under *Picea mariana*, 5.ix.84, D.W.Malloch UAMH 6162.

LITERATURE REPORTS OF CULTURAL CHARACTERS: Modess (1941), Semerdzieva (1965).

REMARKS: As pointed out under *T.imbricatum*, *T.vaccinum* can be distinguished from *T.imbricatum* by pure white to pale pastel coloured colonies, lack of pigmentation in agar and the occasional occurrence of clamp connections. Semerdzieva (1965) recorded clamp connections as being absent while Modess (1941) found clamp connections to be very abundant in aerial hyphae but absent in submerged hyphae. The presence of clamp connections was variable among the three isolates cited above.

46. *Tricholoma virgatum* (Fr.: Fr.) Kummer

MACROMORPHOLOGY: BAF: circular to slightly irregularly circular, 10-15 mm in diameter, sparsely cottony to compact cottony, compact cottony where sectoring, white, with a raised even margin. Reverse brownish grey (5E2) surrounded by brownish orange (5C3) with white at the margin. PDA: ±elliptical, 5-8 mm in diameter, ±cottony, white, with a raised to appressed even margin. Reverse brownish orange (5C3) in centre surrounded by yellowish white (4A2). MN: slightly irregularly circular, 12-14 mm in diameter, floccose sectoring to densely cottony in places, white, hyaline to white at a raised uneven (even in sectored portions) margin. Reverse brownish orange (5C3) in centre surrounded by greyish orange (5B3), with yellowish white (4A2) at the margin. Hagem's: slightly irregularly circular, 15-17 mm in diameter, appressed cottony sectoring to densely cottony, white, hyaline towards raised uneven margin where agar is depressed. Reverse reddish brown (8E8) in centre surrounded by reddish brown (8D7), with greyish yellow (4B3) at the margin.

MICROMORPHOLOGY: Hyphae 2.0-2.6 rarely up to 3.2 um in diameter, hyaline, lacking clamp connections, producing intercalary and terminal swellings when submerged and growing on MN agar, globose to ellipsoidal 7.0-9.8 x 7.8-9.8 um.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-/+), gelatinase (-), degradation of casamino acids (-/+), acidification of BCP-casamino acids agar (-), urease activity (variable), sensitive at 7°C, sensitive at 30°C, sensitive to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), tolerant to malachite green (2ug/mL), sensitive to sodium chloride (10mg/mL), polyphenol oxidase activity (laccase dominant), DBB reaction on non-treated mycelia (yellow).
HABITAT: under conifers in coniferous and mixed woods throughout North America (Miller 1980; Lincoff 1981; McKnight and McKnight 1987; Ovrebo 1989).
ISOLATE EXAMINED: CANADA: ONTARIO: Muskoka District, Dorset, under *Abies balsamea* and *Pinus strobus*, 19.ix.86, L.J.Hutchison UAMH 5798.
LITERATURE REPORTS OF CULTURAL CHARACTERS: Melin (1924).
REMARKS: Melin (1924) reported that *T.virgatum* grew poorly on artificial media.

AMANITACEAE

Amanita

Colonies mostly white and cottony; hyphae lacking clamp connections (except *A.muscaria*); lipase (mostly +), amylase (+, except *A.muscaria*), gelatinase (+), degradation of casamino acids (-), acidification of BCP-casamino acids agar (+, except *A.rubescens*), urease (-, growth present); polyphenol oxidase activity (tyrosinase dominant).

47. *Amanita brunnescens* Atk.

MACROMORPHOLOGY: BAF: irregularly circular, 7-9 mm in diameter, cottony, whitish, with raised even margin. Reverse dark brown (6F8) with pale yellow (4A3) at the margin. Slight brown pigment diffusing into the agar. PDA: ±irregularly circular, 6-15 mm in diameter, sparsely cottony, greyish yellow (4B3) in centre, white elsewhere, with raised uneven margin. Reverse dark brown (6F8) with pale yellow (4A3) at the margin. MN: ±irregularly circular, 5-10 mm in diameter, sparsely cottony, ±dull white, with a raised uneven margin. Reverse dark brown (6F8) with pale yellow (4A3) at the margin. Hagem's: irregularly circular, 8-9 mm in diameter, sparsely cottony, ±dull white, with a raised uneven margin. Reverse dark brown (6F8) surrounded by pale yellow (4A3) at the margin.
MICROMORPHOLOGY: Hyphae 2.0-3.9 um in diameter, hyaline, lacking clamp connections.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (+), amylase (+), gelatinase (+), degradation of casamino acids (-), acidification of BCP-casamino acids agar (+), urease activity (-, growth absent), sensitive at 7°C, tolerant at 30°C, tolerant to benomyl (10ug/mL), semi-tolerant to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), tolerant to malachite green (2ug/mL), sensitive to sodium chloride (10mg/mL), polyphenol oxidase activity (tyrosinase dominant), DBB reaction on non-treated mycelia (yellow).

HABITAT: under Quercus in deciduous forest zone of eastern North America (Miller 1980; Lincoff 1981; McKnight and McKnight 1987).
ISOLATE EXAMINED: USA: MASSACHUSETTS: Franklin Co., Mt.Toby Forest Reserve, 8 km N of Amherst, under Quercus rubra and Tsuga canadensis, 12.viii.86, R.G.Thorn UAMH 5942.

48. Amanita citrina (Schaeff.) Pers.
MACROMORPHOLOGY: BAF: circular, 18-22 mm in diameter, cottony, sparsely at margin, white, with a raised ±even margin. Reverse brown (7E8) in centre surrounded by greyish orange (6B6), with pale yellow (4A3) at the margin, with minute cracks occurring in agar beneath centre of the colony. PDA: ±circular, 20-25 mm in diameter, cottony, sparsely at margin, white, with a raised ±even margin. Reverse reddish brown (7E8) in centre surrounded by greyish orange (6B6), with pale yellow (4A3) at the margin, with minute cracks in agar beneath centre of the colony. MN: slightly irregularly circular to irregularly circular, 22-26 mm in diameter, cottony, white, with a raised even margin. Reverse reddish brown (8E8) mixed with brownish orange (6C6), with pale yellow (4A3) at the margin. Hagem's: slightly irregularly circular, (23-)27-32 mm in diameter, cottony, lacunose, white, with a raised ±even margin. Reverse brown (6E8) mixed with greyish orange (6B5), surrounded by pale yellow (4A3) at the margin, with radial grooves visible from beneath the colony.
MICROMORPHOLGY: Hyphae (1.3-)2.0-3.2 um in diameter, hyaline, lacking clamp connections, producing only a few to rare swellings when submerged, particularly when grown on MN and Hagem's.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (+), amylase (+), gelatinase (+), degradation of casamino acids (-), acidification of BCP-casamino acids agar (+), urease activity (-, growth present), sensitive at 7°C, tolerant at 30°C, semi-tolerant to benomyl (10ug/mL), tolerant to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), sensitive to malachite green (2ug/mL), tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (tyrosinase dominant), DBB reaction on non-treated mycelia (negative).
HABITAT: associated with Pinus in coniferous and mixed woods, eastern North America (Miller 1980; Lincoff 1981).
ISOLATE EXAMINED: CANADA: QUEBEC: Portneuf Co., St.Augustin, under Pinus resinosa, Populus tremuloides, Salix spp., 1981, C.Godbout CRBF 111.
LITERATURE REPORTS OF CULTURAL CHARACTERS: Modess (1941) as A.mappa, Semerdzieva (1965), Kowalski (1974), Campbell and Petersen (1975).
REMARKS: Campbell and Petersen (1975) recorded and illustrated basidia with 2-7 sterigmata in vitro for one of their isolates of A.citrina. This fact, along with good growth on malt agar suggests their culture had been contaminated with a species of Sistotrema, a corticioid fungus which normally produces basidia with 4-8 sterigmata in vitro (Käärik and Rennerfelt 1957; Siepmann 1969).

49. Amanita flavoconia Atk.
MACROMORPHOLOGY: BAF: ±circular, 29-30 mm in diameter, cottony, white, with a raised even margin. Reverse brownish orange (5C5) under plug, greyish orange (5B4) elsewhere, with yellowish white (4A2) near the margin, with radial grooves visible beneath the colony. PDA: circular, 34-35 mm in diameter, cottony, white, with a raised even margin. Reverse brownish orange (6C5) under plug, pale orange (5A3) elsewhere

with yellowish white (4A2) near the margin, with radial grooves visible beneath the colony. MN: circular, 12-16 mm in diameter, cottony, reaching lid of petri dish, white, with a raised even margin where agar is depressed. Reverse brown (6E8) in centre, surrounded by greyish brown (6B4) with yellowish white (4A2) at the margin. Hagem's: circular, 28-32 mm in diameter, cottony, radially lacunose, white, with raised even margin. Reverse brownish orange (5C5) in centre, pale orange (5A3) elsewhere, with yellowish white (4A2) at the margin, with radial grooves visible beneath the colony.

MICROMORPHOLOGY: Hyphae (1.3-)1.6-3.2(-3.9) um in diameter, hyaline, lacking clamp connections.

PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (+), amylase (+), gelatinase (+), degradation of casamino acids (-), acidification of BCP-casamino acids agar (+), urease activity (-, growth present), sensitive at 7°C, tolerant at 30°C, sensitive to benomyl (10ug/mL), tolerant to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), tolerant to malachite green (2ug/mL), semi-tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (negative), DBB reaction on non-treated mycelia (red).

HABITAT: in coniferous and mixed woods, eastern North America (Miller 1980; Lincoff 1981; McKnight and McKnight 1987).

ISOLATE EXAMINED: CANADA: QUEBEC: Portneuf Co., St.Augustin, under *Pinus resinosa*, *Populus tremuloides*, *Salix* spp., 1981, C.Godbout CRBF 109.

LITERATURE REPORTS OF CULTURAL CHARACTERS: Campbell and Petersen (1975).

50. *Amanita muscaria* (L.: Fr.) Pers.

MACROMORPHOLOGY: BAF: ±circular to irregular, (6-)18-23(-45) mm in diameter, sometimes severely restricted in growth, cottony, sometimes densely cottony, occasionally lacunose, white, rarely pale grey (B1), with a raised even margin where agar is sometimes depressed. Reverse brown (6E8) to dark brown (6F4-6F8) under plug, surrounded by light orange (6A5) to greyish orange (5B3-5B4), with white to pale yellow (4A3) through to orange white (5A2) at the margin, with agar sometimes cracking below the colony. PDA: ±circular to irregularly circular, (7-)18-40(-54) mm in diameter, sometimes severely restricted in growth, thinly to densely cottony, felty at times, sometimes lacunose, white, with a raised even margin where agar is sometimes depressed. Reverse brownish orange (7C6) to brown (7E7-7E8) through to dark brown (6F8) in centre, surrounded by pale orange (5A4) to brownish orange (6C5), with yellowish white (3A2) to orange white (5A2) at the margin, with the agar sometimes cracking below the colony. MN: ±circular to irregularly circular, 21-44(-57) mm in diameter, cottony to densely cottony, sometimes felty, ±lacunose, white, rarely with tinges of pale grey (B1), with a raised even margin where agar is rarely depressed. Reverse yellowish brown (5E5) to brown (7E8) in centre surrounded by brownish orange (6C4) to reddish brown (9E8), with yellowish white (4A2) to pale orange (5A3) at the margin, with the agar sometimes cracking below the colony. Hagem's: slightly irregularly circular to irregular, (6-)19-42 mm in diameter, sometimes restricted in growth, cottony to compact cottony, sometimes lacunose, white, with a raised even margin where agar is rarely depressed. Reverse light brown (6D6) to dark brown (7F8) under plug, surrounded by light orange (6A5) to brown (6E8), with white to pale orange (6A3) at the margin, where agar is sometimes cracking below the colony.

MICROMORPHOLOGY: Hyphae (1.3-)2.0-2.6(-3.2) rarely up to 4.5 um in diameter, hyaline, possessing clamp connections at irregular intervals.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (+), amylase (-), gelatinase (-/+), degradation of casamino acids (-), acidification of BCP-casamino acids agar (+), urease activity (-, growth present), sensitive at 7°C, sensitive to semi-tolerant at 30°C, sensitive to semi-tolerant to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), sensitive to semi-tolerant to rose bengal (10ug/mL), sensitive to malachite green (2ug/mL), variable response to sodium chloride (10mg/mL), polyphenol oxidase activity (tyrosinase dominant), DBB reaction on non-treated mycelia (negative).
HABITAT: deciduous and coniferous woods, throughout North America (Miller 1980; Lincoff 1981; McKnight and McKnight 1987).
ISOLATES EXAMINED: CANADA: ONTARIO: Timiskaming District, Burt Twp., Burt Lake, under Populus tremuloides, Betula papyrifera, Alnus sp. and Abies balsamea, 27.viii.80, D.G.Lahaie UAMH 6142; under Pinus banksiana, 19.viii.86, L.J.Hutchison UAMH 5822; under Pinus banksiana and Populus tremuloides, 22.viii.86, L.J.Hutchison UAMH 5796; York Co., North York, under Pinus strobus, Quercus rubra, Tsuga canadensis and Tilia americana, 23.ix.84, L.J.Hutchison UAMH 5637.
LITERATURE REPORTS OF CULTURAL CHARACTERS: Melin (1923b), Hatch and Hatch (1933), Modess (1941) Sobotka (1954), Semerdzieva (1965), Kowalski (1974), Campbell and Petersen (1975), Jenkins and Petersen (1976).
REMARKS: Amanita muscaria is distinctive among all five Amanita species tested by lacking the ability to degrade amylose. As well, it is also distinctive by producing clamp connections but these are only found in the older hyphae (astatocoenocytic). Melin (1923b), Campbell and Petersen (1975) and Jenkins and Petersen (1976) reported absence of clamps for A.muscaria but probably looked only at younger hyphae at the colony margin as Modess (1941), Semerdzieva (1965) and Kowalski (1974) reported clamp connections.

51. Amanita rubescens (Pers.: Fr.) Pers.
MACROMORPHOLOGY: BAF: circular, 13-14(-26) mm in diameter, floccose to cottony, sometimes thinly cottony, white to whitish, with an ± appressed uneven hyaline margin. Reverse dark brown (8F8) under plug, orange white (5A2) elsewhere. PDA: slightly irregularly circular, (7-)15-20 mm in diameter, appressed to subfelty to thinly cottony, white, with an appressed uneven hyaline margin. Reverse dark brown (8F8) under plug, greyish red (8B4) elsewhere, with orange white (6A2) at the margin.
MN: irregularly circular, 8-14 mm in diameter, appressed to thinly cottony to cottony, white with appressed irregular hyaline margin. Reverse brownish orange (7C4), sometimes brownish grey (5F2) under plug, with orange white (5A2) at the margin. Hagem's: circular, 18-27 mm in diameter, cottony to subfelty, sometimes slightly lacunose, white to yellowish grey (4B2) with an appressed to slightly raised uneven hyaline margin. Reverse dark brown (7F8) under plug, surrounded by a band of reddish brown (8E8) then surrounded by orange (6A6), with yellowish white (4A2) at the margin.
MICROMORPHOLOGY: Hyphae (1.3-)2.0-3.2 rarely up to 4.5 um in diameter, hyaline, frequently irregular, lacking clamp connections.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (+), gelatinase (-/+), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-), urease activity (-, growth present),

sensitive at 7°C, sensitive at 30°C, sensitive to benomyl (10ug/mL), semi-tolerant to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), tolerant to malachite green (2ug/mL), semi-tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (tyrosinase dominant), DBB reaction on non-treated mycelia (yellow).
HABITAT: associated with broad-leaved hosts in deciduous and coniferous forests, eastern North America (Miller 1980; Lincoff 1981; McKnight and McKnight 1987).
ISOLATE EXAMINED: CANADA: ONTARIO: Timiskaming District, Burt Twp., Burt Lake, in forest of _Picea glauca_ and _Pinus banksiana_ with _Betula papyrifera_ nearby, 17.viii.80, D.W.Malloch UAMH 6143.
LITERATURE REPORTS OF CULTURAL CHARACTERS: Mikola (1955), Semerdzieva (1965), Campbell and Petersen (1975), Miller _et al_. (1983).
REMARKS: The hyphae of _A.rubescens_ were rather irregular in appearance, an observation previously made by Campbell and Petersen (1975) and Miller _et al_. (1983).

CORTINARIACEAE

Hebeloma

Colony morphology variable; hyphae possessing clamp connections; lipase (-), amylase (-, except _H.crustuliniforme_), urease (+, growth present); semi-tolerant to tolerant at 7°C; sensitive to benomyl, semi-tolerant to tolerant to cycloheximide and malachite green; diazonium blue B reaction on non-treated mycelia (yellow).

52. _Hebeloma crustuliniforme_ (Bull.) Quél.
MACROMORPHOLOGY: BAF: circular to irregularly circular, (12-)20-40 mm in diameter, cottony to cottony-felty, sometimes lacunose, mycelium sometimes reaching lid of petri dish, white, often with an appressed to sometimes raised even hyaline margin where agar is sometimes depressed. Reverse brownish orange (7C7) to dark brown (7F8) under plug, surrounded by light orange (6A4) to brown (6E8), with yellowish white (4A2) to orange white (5A2) through to light yellow (4A4) at the margin. PDA: circular to irregularly circular, (12-)17-51 mm in diameter, cottony to floccose to sparsely flocculose, sometimes mycelium reaching lid of petri dish, white, rarely greyish orange (5B4) with a submerged to appressed to raised even often hyaline margin. Reverse greyish orange (5B5) to brown (6E8) in centre surrounded by pale orange (5A3) to greyish orange (6B6), with yellowish white (4A2) to orange white (6A2) at the margin. MN: circular to rarely polygonal, (16-)23-55 mm in diameter, cottony to felty, sometimes floccose, occasionally lacunose, sometimes mycelium reaching lid of petri dish, white, with a submerged to appressed to raised even sometimes hyaline margin. Reverse brownish orange (5C5-6C4) to brown (7E8) to rarely greyish red (8B3) under plug, rest of colony pale orange (5A3) to light orange (6A4) through to greyish orange (6B5), with yellowish white (4A2) at the margin. Hagem's: circular to slightly irregularly circular (rarely slightly elliptical), (12-)22-44 mm in diameter, sparsely cottony to cottony to felty, sometimes lacunose, sometimes mycelium touching lid of petri dish, white, with a raised even margin. Reverse brownish orange (7C5) to brown (6E8) rarely greyish red (8C4) in centre, rest of colony pale orange (5A3) to light orange (6A4) through to greyish orange (6B4), with yellowish white (4A2) at the margin.

MICROMORPHOLOGY: Hyphae 2.0-3.2(-3.9) um in diameter, hyaline with clamp connections frequently doughnut shaped.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (+), gelatinase (-), degradation of casamino acids (+), acidification of BCP-casamino acids agar (+), urease activity (+, growth present), semi-tolerant (rarely sensitive) at 7°C, sensitive to semi-tolerant at 30°C, sensitive to benomyl (10ug/mL), semi-tolerant to tolerant to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), semi-tolerant to tolerant to malachite green (2ug/mL), semi-tolerant to tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (equivalent), DBB reaction on non-treated mycelia (yellow).
HABITAT: deciduous or mixed woods, throughout North America (Miller 1980; Pomerleau 1980; Lincoff 1981; McKnight and McKnight 1987).
ISOLATES EXAMINED: CANADA: ALBERTA: Slave Lake Forest, in Picea glauca woods, 4.ix.85, R.S.Currah UAMH 5251; Rocky-Clearwater Forest, under Picea glauca and Populus, 6.viii.86, R.S.Currah UAMH 5453; in mixed Picea glauca, P.mariana, Populus and Pinus contorta woods, 13.viii.86, R.S.Currah UAMH 5457; 3.ix.86, R.S.Currah UAMH 5460.
REMARKS: The ability of H.crustuliniforme to degrade amylose distinguishes it from the other four Hebeloma species examined.

53. Hebeloma cylindrosporum Romagn.
MACROMORPHOLOGY: BAF: ±circular, 48-56 mm in diameter, floccose becoming matted, lacunose, white or white in centre, surrounded by a band of light brown (6D8), with an appressed even white margin. Reverse pale yellow (4A3) often tinged with light brown (6D8), with agar severely cracking under the colony, sometimes colony uplifting and separating from bottom of petri dish. PDA: circular, 66-85 mm in diameter, flocculose, deeply lacunose, white, with an appressed ±even hyaline margin. Reverse pale yellow (4A3), with large cracks occurring in the agar below centre of the colony. MN: circular, 73-76 mm in diameter, flocculose, white, with an appressed ±even hyaline margin. Reverse yellowish white (4A2). Hagem's: circular, 50-60 mm in diameter, floccose to flocculose, white, with a raised even to uneven margin. Reverse brownish orange (5C3) under plug, pale yellow (4A3) to light yellow (4A4) elsewhere.
MICROMORPHOLOGY: Hyphae 1.3-3.2(-3.9) um in diameter, hyaline, possessing clamp connections.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-/+), gelatinase (+), degradation of casamino acids (+), acidification of BCP-casamino acids agar (-), urease activity (+, growth present), semi-tolerant at 7°C, tolerant at 30°C, sensitive to benomyl (10ug/mL), tolerant to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), tolerant to malachite green (2ug/mL), tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (negative), DBB reaction on non-treated mycelia (yellow).
HABITAT: in sandy coniferous forests under Pinus (Orton 1987).
ISOLATE EXAMINED: FRANCE: Arcachon, under Pinus pinaster, 1977, D.Mousain CRBF 38.
REMARKS: H.cylindrosporum can be distinguished from the other four species of Hebeloma examined by its faster growth rate, high growth tolerance at 30°C and negative reaction for laccase and tyrosinase.

This species as yet has not been recorded from North America.

54. Hebeloma longicaudum (Pers.: Fr.) Kummer
MACROMORPHOLOGY: BAF: circular to slightly irregularly circular, 32-40 mm in diameter, cottony to felty, sometimes lacunose, sometimes mycelium touching lid of petri dish, white, hyaline at an appressed to submerged (sometimes raised) even margin. Reverse brownish orange (7C6) to reddish brown (8D8) in centre surrounded by greyish orange (6B5-6B6), with pale yellow (4A3) to pale orange (5A3) at the margin, with the agar sometimes cracking below the colony. PDA: circular to irregularly circular, 29-49 mm in diameter, cottony to subfelty, mycelium reaching lid of petri dish, white, with an appressed to submerged (sometimes raised) even margin. Reverse greyish red (7B6) to light orange (6A4) with pale yellow (4A3) to orange white (5A2) at the margin. MN: circular to irregularly circular, (39-)47-50(-59) mm in diameter, cottony to thinly cottony, mycelium reaching lid of petri dish, white, with a raised even margin. Reverse light yellow (4A5) to greyish orange (6B6) in centre, with pale yellow (4A3) to pale orange (5A3) at the margin. Hagem's: irregularly circular to irregular, 32-40(-49) mm in diameter, cottony, sometimes touching lid of petri dish, white, with a raised ±even margin. Reverse greyish orange (6B6) to greyish red (7B6) in centre, surrounded by greyish orange (6B5) to pale yellow (4A3) at the margin.
MICROMORPHOLOGY: Hyphae 2.0-3.2(-3.9) um in diameter, hyaline, possessing clamp connections which may frequently be doughnut-shaped.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (+), degradation of casamino acids (+), acidification of BCP-casamino acids agar (+), urease activity (+, growth present), semi-tolerant at 7°C, variable response at 30°C, sensitive to benomyl (10ug/mL), tolerant to cycloheximide (2ug/mL), sensitive to rose bengal (10ug/mL), tolerant to malachite green (2ug/mL), tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (equivalent), DBB reaction on non-treated mycelia (yellow).
HABITAT: in deep moss under conifers (particularly Picea) in boreal coniferous forest zone across northern North America (Redhead 1979; Pomerleau 1980).
ISOLATES EXAMINED: CANADA: QUEBEC: Nouveau Québec Territory, 1 km E of Schefferville airport, in Pleurozium carpet under Picea mariana, Salix sp., Larix laricina and Alnus rugosa, 26.viii.84, D.W.Malloch UAMH 6064, UAMH 6149.

55. Hebeloma mesophaeum (Pers.) Quél.
MACROMORPHOLOGY: BAF: circular to slightly polygonal, 22-40 mm in diameter, cottony to floccose, sometimes funiculose in centre, greyish brown (6D3-7D3) surrounded by dark brown (6F5), with greyish red (7B3-8C3) at a submerged to appressed to raised even margin. Reverse dark brown (6F8-8F8) sometimes surrounded by light brown (6D4), with brownish orange (5C3) to greyish red (8C5) at the margin. Sometimes slight brown pigment diffusing into the agar. PDA: circular to slightly irregularly circular, 25-38 mm in diameter, cottony to cottony-felty, light brown (6D4-7D6), sometimes greyish yellow (4B5) in centre, with greyish red (8C4) towards an appressed to submerged even margin. Reverse dark brown (7F6-7F8) in centre surrounded by light brown (7D6-7D7), with greyish orange (6B5) to pale red (7A3) at the margin. Slight pigment diffusing into the agar. MN: ±circular, 31-48 mm in diameter, cottony-felty, sometimes only cottony at centre and margin and appressed in between,

yellowish brown (5D4) to greyish yellow (4B5) at centre, surrounded by yellowish brown (5F5) to light brown (6D8), with pale yellow (4A3) to reddish grey (7B2) at a submerged to appressed to ±raised even margin. Reverse dark brown (6F8-8F8) in centre surrounded by brownish orange (6C3) to reddish brown (8E8), then sometimes further surrounded by band of brown (6E4) to pale orange (5A3), with yellowish white (4A2) to greyish orange (6B5) at the margin. Hagem's: ±circular to slightly irregularly circular, 27-43 mm in diameter, floccose to cottony to somewhat matted, light brown (6D5) to greyish brown (6D3) in centre, surrounded by reddish brown (8E6), with pinkish white (7A2-7B2) at a submerged to raised even to uneven (somewhat bayed at times) margin. Reverse dark brown (6F8-7F8) in centre, surrounded by reddish brown (8E8) sometimes brown (6E4) to yellowish brown (5D5), with greyish orange (6B5) to yellowish white (4A2) at the margin.
MICROMORPHOLOGY: Hyphae 2.0-3.2(-3.9) um in diameter, hyaline, possessing clamp connections, rarely producing intercalary swellings.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (+), urease activity (+, growth present), semi-tolerant at 7°C, sensitive at 30°C, sensitive to benomyl (10ug/mL), variable response to cycloheximide (2ug/mL), sensitive to rose bengal (10ug/mL), tolerant to malachite green (2ug/mL), sensitive to sodium chloride (10mg/mL), polyphenol oxidase activity (tyrosinase dominant/equivalent), DBB reaction on non-treated mycelia (yellow).
HABITAT: coniferous forests, particularly in disturbed sites, throughout North America (Bruchet 1970; Miller 1980; McKnight and McKnight 1987).
ISOLATES EXAMINED: CANADA: ONTARIO: York Co., Whitchurch Conservation Area nr. Ballantrae, beneath Pinus strobus, 11.x.87, L.J.Hutchison UAMH 6081; QUEBEC: Quebec Co., Cap Rouge, under Populus tremuloides, 1980, C.Godbout CRBF 99.
REMARKS: H.mesophaeum was the only Hebeloma examined in this study which possessed brown colonies as opposed to white colonies for the other four species.

56. Hebeloma velutipes Bruchet
MACROMORPHOLOGY: BAF: ±circular to slightly irregularly circular, 17-20 mm in diameter, cottony to felty, uplifted, white, with an appressed even hyaline margin. Reverse brownish orange (7C7) surrounded by pale orange (5A3), with yellowish white (4A2) at the margin. PDA: slightly irregularly circular, 18-19 mm in diameter, cottony, white, hyaline at an appressed to submerged even margin. Reverse brownish orange (6C6) surrounded by light orange (6A5), with orange white (5A2) at the margin. MN: slightly irregularly circular, 24-26 mm in diameter, appressed to flocculose in centre, radially lacunose, greyish orange (5B4) with white at centre, with an appressed even margin. Reverse brownish orange (7C4) surrounded by greyish orange (6B5), with orange white (6A2) at the margin. Hagem's: slightly irregularly circular, 21-22 mm in diameter, cottony to felty, white, with a raised even margin. Reverse brownish orange (6C5) in centre with greyish orange (6B5) elsewhere.
MICROMORPHOLOGY: Hyphae (1.3-)2.0-2.6(-3.2) um in diameter, hyaline, possessing clamp connections.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-), urease activity (+, growth absent), semi-

tolerant at 7°C, tolerant at 30°C, sensitive to benomyl (10ug/mL), semi-tolerant to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), tolerant to malachite green (2ug/mL), tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (laccase dominant), DBB reaction on non-treated mycelia (yellow).
HABITAT: deciduous and mixed woods, especially with Betulaceae (Bruchet 1970; Moser 1983).
ISOLATE EXAMINED: CANADA: QUEBEC: Québec Co., Ste.Foy, under *Populus tremuloides* and *Pinus banksiana*, 1981, C.Godbout CRBF 116.

Cortinarius

Colony morphology variable; hyphae of most but not all species possessing clamp connections; urease (-/+, growth absent); semi-tolerant to tolerant to benomyl (except *C.brunneus*) and rose bengal (except *C.mucosus*); diazonium blue B reaction on non-treated mycelia (negative).

57. *Cortinarius allutus* Fr.

MACROMORPHOLOGY: BAF: irregularly circular to irregular, (15-)21-39 mm in diameter, cottony, lacunose, white with tinges of light violet (19A4), with a raised even margin. Reverse pale orange (6A3) with tinges of light violet (19A4), with white at the margin, with the agar cracking beneath the colony. PDA: slightly irregularly circular to irregularly circular, 20-33 mm in diameter, cottony, white, sometimes with hint of pale violet (18A3) at the raised even margin. Reverse dark brown (6F8) in centre, surrounded by brownish orange (6C6) with yellowish white (4A2) at the margins. MN: irregularly circular, 17-32 mm in diameter, cottony, lacunose, white, with a raised even margin. Reverse greyish brown (6E3) mixed with greyish orange (6B4), with yellowish white (4A2) at the margin, with the agar slightly cracking beneath the colony. Hagem's: irregularly circular, 24-30 mm in diameter, cottony, becoming matted in the centre, deeply lacunose, white, with a raised even margin where agar is depressed. Reverse greyish orange (6B3) in centre, surrounded by dark blue (19E4), with pale yellow (4A3) at the margin, with the agar cracking below the colony, with radial grooves visible beneath the colony.
MICROMORPHOLOGY: Hyphae (1.0-)1.6-2.6(-4.2) um in diameter, hyaline, possessing clamp connections, when submerged slightly twisted and possessing a few large swellings, globose to ellipsoidal, 18-26 x 22-33 um.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (+), gelatinase (+), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-), urease activity (-, growth absent), sensitive at 7°C, sensitive at 30°C, tolerant to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), tolerant to malachite green (2ug/mL), tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (negative), DBB reaction on non-treated mycelia (negative).
HABITAT: in coniferous forests, particularly under *Picea* (Lange 1938; Moser 1960).
ISOLATE EXAMINED: CANADA: ALBERTA: Rocky-Clearwater Forest, in mixed *Picea glauca*, *Picea mariana*, *Pinus contorta* woods, 6.viii.86, R.S.Currah UAMH 5474.

58. Cortinarius amoenolens R.Henry

MACROMORPHOLOGY: BAF: irregularly circular to irregular, 16-34 mm in diameter, cottony, violet white (18A2), with a raised even margin. Reverse brown (6E8) in centre, surrounded by pale yellow (4A3) with tinges of dull lilac (16C3), with slight cracking of the agar beneath centre of the colony. PDA: irregularly circular to irregular, 16-29 mm in diameter, cottony, lacunose, white to pale yellow (4A3) in centre with violet white (18A2) at raised even margin. Reverse brown (7E8) in centre, surrounded by greyish orange (6B4), with mottling of greyish violet (15D5) and white at the margin. MN: irregularly circular to irregular, 13-19 mm in diameter, cottony, lacunose, white to violet white (17A2), with a raised even margin. Reverse dark brown (7F8) to light brown (7D8) in centre, surrounded by greyish magenta (14E7) then surrounded by a band of yellowish grey (4B3), with white at the margin, with radial grooves visible beneath the colony. Hagem's: irregularly circular to irregular, 13-20 mm in diameter, cottony, lacunose, white, often with violet white (17A2) at a raised even margin. Reverse light brown (6D4) mixed with dark brown (6F8) surrounded by dull violet (15D3), white at the margin, with the agar cracking beneath the colony.

MICROMORPHOLOGY: Hyphae 1.3-2.6(-3.9) um in diameter, hyaline, possessing clamp connections, producing a few globose to ellipsoidal swellings when submerged and grown on Hagem's agar.

PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (+), gelatinase (+), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-), urease activity (-, growth absent), sensitive at 7°C, sensitive at 30°C, tolerant to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), tolerant to malachite green (2ug/mL), semi-tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (tyrosinase dominant), DBB reaction on non-treated mycelia (negative).

HABITAT: coniferous and deciduous woods (Moser 1983).

ISOLATE EXAMINED: CANADA: ALBERTA: Rocky-Clearwater Forest, in mixed Picea mariana and Picea glauca woods, 28.vii.86, R.S.Currah UAMH 5534.

REMARKS: Morphologically, C.amoenolens may be confused with cultures of C.glaucopus and C.allutus because of the ephemeral violet colouration of the young colonies of all three species. The latter two, however, lack tyrosinase activity.

59. Cortinarius anomalus (Fr.: Fr.) Fr.

MACROMORPHOLOGY: BAF: irregular, 10-17 mm in diameter, velvety to cottony, lacunose, white, often with violet white (17A2) to pale violet (17A3) at a raised even margin. Reverse greyish magenta (13E3) to dark violet (16F3) in centre surrounded by greyish magenta (13C3) to greyish violet (15C5), sometimes white at the margin, often with agar cracking below the colony. PDA: irregularly circular to irregular, 9-15 mm in diameter, cottony to felty, white, often with pale violet (17A3) at a raised (sometimes appressed) even margin where agar is depressed. Reverse dull violet (15E3-16E3) in centre surrounded by dull lilac (15C3) to light grey (15C1), with white at the margin. MN: irregularly circular, 8-15 mm in diameter, cottony, white, with raised even margin where agar is sometimes slightly depressed. Reverse dull violet (15E3) to violet grey (16D2) in centre, sometimes surrounded by pale orange (5A3), with white at the margin. Hagem's: irregular, 12-17 mm in diameter, cottony, slightly lacunose, white, often with violet white

(17A2) at a raised even margin. Reverse dull violet (15D4-16E3) to medium grey (15E1) surrounded by greyish orange (6B3), with white at the margin, with the agar sometimes cracking below the colony.

MICROMORPHOLOGY: Hyphae 2.0-3.9(-4.6) rarely up to 6.0 um in diameter, hyaline, lacking clamp connections, frequently producing terminal swellings, ellipsoidal to ovoid in shape 6.5-23 x 7-35 um, with only slightly thicker walls than adjacent hyphae, never breaking away unless mycelium crushed under cover slip, also producing intercalary swellings, globose to ellipsoidal 5.5-17.0 x 7.0-28 um.

PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (+), amylase (-/+), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (+), urease activity (+, growth absent), sensitive at 7°C, sensitive at 30°C, tolerant to benomyl (10ug/mL), semi-tolerant to cycloheximide (2ug/mL), semi-tolerant to rose bengal (10ug/mL), sensitive to malachite green (2ug/mL), semi-tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (equivalent), DBB reaction on non-treated mycelia (negative).

HABITAT: deciduous, mixed and coniferous forests (Pomerleau 1980; Moser 1983).

ISOLATES EXAMINED: CANADA: NEW BRUNSWICK: Charlotte Co., St.Andrews Twp., 3 km E of Chamcook, under Abies balsamea, 3.ix.85, D.W.Malloch UAMH 5929; ONTARIO: Timiskaming District, Burt Twp., Burt Lake, under Populus tremuloides and Pinus banksiana, 8.ix.82, D.W.Malloch DM 95 (culture lost).

REMARKS: C.anomalus possessed abundant ellipsoidal to ovoid terminal swellings on the hyphae, a feature which was quite characteristic for this species.

60. Cortinarius brunneus (Pers.:Fr.) Fr.

MACROMORPHOLOGY: BAF: circular, 17-40 mm in diameter, floccose to funiculose, sometimes cottony, white becoming pale yellow (3A3) to pale orange (5A3) in centre, with a submerged to sometimes raised even to slightly plumose margin. Reverse greyish yellow (4C5) to pale orange (5A3) through to yellowish brown (5F6) under plug, deep yellow (4A8) to orange (5B8) elsewhere. Yellowish pigment diffusing into the agar.

PDA: circular, (10-)21-46 mm in diameter, velvety to flocculose, sometimes cottony, white, with an appressed to sometimes raised even margin. Reverse brownish yellow (5C8) to light brown (6D8) under plug surrounded by greyish yellow (4B6) to orange (5B7), light yellow (4A5) to deep yellow (4A8) elsewhere. Yellowish pigment diffusing into the agar. MN: circular to slightly irregularly circular, 34-37 mm in diameter, floccose to felty, slightly zonate due to ring of funiculose cords which arise from below the colony, white, with a submerged to appressed (sometimes raised) even margin. Reverse greyish brown (5D3) to brownish orange (7C5) under plug pale yellow (4A3) elsewhere.

Hagem's: ±circular, 35-43 mm in diameter, felty to floccose, somewhat zonate due to funiculose cords arising from below colony, white, with a submerged to appressed (sometimes raised) even margin. Reverse yellowish brown (5E8-5F8) below plug, sometimes pinkish white (7A2), pale yellow (4A3) to light orange (5A4) elsewhere, with white mycelial strands often radiating from below centre of colony to arise above surface to form zonations of funiculose cords.

MICROMORPHOLOGY: Hyphae (1.0-)1.6-2.6 rarely up to 3.2 um in diameter, hyaline, lacking clamp connections although incomplete clamps are

frequently present, occasionally producing intercalary swellings, ellipsoidal to globose 5.6-10.0 x 6.3-10.5 um.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (+), amylase (+), gelatinase (+), degradation of casamino acids (-), acidification of BCP-casamino acids agar (+), urease activity (+, growth absent), sensitive at 7°C, tolerant at 30°C, sensitive to benomyl (10ug/mL), semi-tolerant to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), tolerant to malachite green (2ug/mL), sensitive to sodium chloride (10mg/mL), polyphenol oxidase activity (laccase dominant), DBB reaction on non-treated mycelia (negative).
HABITAT: in coniferous forests (Moser 1983; Gerhardt 1984).
ISOLATE EXAMINED: CANADA: ONTARIO: Timiskaming District, Dunmore Twp., Dunmore Lake, in moss carpet under Picea mariana, 18.viii.80, D.W.Malloch UAMH 5793.
REMARKS: C.brunneus was distinct in exuding yellow pigments into the agar media (BAF and PDA) and was also the only Cortinarius to exhibit sensitivity to benomyl. It was the only fungus among the 96 species examined which unequivocally degraded pectin. This character is common among non-mycorrhizal Basidiomycetes, and may indicate that UAMH 5793 is a non-mycorrhizal basidiomycetous contaminant rather than the true C.brunneus.

61. Cortinarius glaucopus (Schaeff.: Fr.) Fr.
MACROMORPHOLOGY: BAF: circular to elliptical to irregularly circular, 19-28 mm in diameter, felty to cottony, lacunose, white to yellowish white (3A2) in centre, sometimes with bluish white (22A2) at a raised even margin where agar is sometimes depressed. Reverse brown (6E6-7E8) in centre surrounded by orange (6A6) or greyish violet (17D4), with white or yellowish white (4A2) at the margin, with the agar cracking beneath centre of the colony, with radial grooves visible beneath the colony. PDA: slightly irregularly circular, 23-38 mm in diameter, cottony becoming matted in centre, slightly lacunose, white to pale yellow (4A3) in centre, surrounded by white at a raised even margin. Reverse yellowish brown (5E8) to dark brown (6F8) in centre, surrounded by yellowish white (4A2) to light orange (6A5), sometimes band of violet grey (17B2) surrounding this, with orange white (5A2) to white at the margin. MN: ±circular to irregularly circular, (20-)25-51 mm in diameter, cottony, lacunose, white to yellowish white (4A2) in centre, white to slightly violet white (18A2) at a raised even margin where agar is often depressed. Reverse dark brown (7F8) to brownish red (8C8) in centre, surrounded by greyish orange (6B6) to greyish red (7B3) often with a band of dull lilac (15C3) surrounding this, white at the margin, with radial grooves visible beneath the colony, with the agar slightly cracking under the colony. Hagem's: circular to irregularly circular, 22-37 mm in diameter, appressed cottony to cottony, lacunose, white to yellowish white (4A2) with white at a raised even margin. Reverse yellowish brown (5E8) to light brown (7D8) under plug, surrounded by greyish orange (5B6) to greyish red (7B5), with yellowish grey (4B2) to lilac grey (15B2) at the margin, with radial grooves visible beneath colony.
MICROMORPHOLOGY: Hyphae (1.3-)2.0-3.9 rarely up to 4.9 um in diameter, hyaline, clamp connections present, infrequently producing globose to ellipsoidal swellings, 7.8-13.0 x 7.8-15.6 um. Oleiferous hyphae very rare.

PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-/+), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-/+), urease activity (+, growth absent), sensitive at 7°C, sensitive at 30°C, tolerant to benomyl (10ug/mL), semi-tolerant to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), sensitive to malachite green (2ug/mL), semi-tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (negative/laccase dominant), DBB reaction on non-treated mycelia (negative).
HABITAT: under conifers in coniferous and mixed woods, particularly in western North America (Miller 1980; Lincoff 1981; McKnight and McKnight 1987).
ISOLATES EXAMINED: CANADA: ALBERTA: Edson Forest, in *Pinus contorta* forest, 6.viii.86, R.S.Currah UAMH 5471; Rocky-Clearwater Forest, under *Populus tremuloides* and *Picea glauca*, 6.viii.86, R.S.Currah UAMH 5558.

62. *Cortinarius mucosus* (Bull.: Fr.) Fr.
MACROMORPHOLOGY: BAF: ellipsoidal, 17-21 mm in diameter, appressed, very funiculose at centre, yellowish white (4A2), with an even margin. Reverse brownish orange (5C5) in centre surrounded by orange white (5A2). PDA: ellipsoidal, 5 mm in diameter, appressed, hyaline, with an even margin. Reverse brownish orange (5C4) with orange white (5A2) at the margin. MN: ellipsoidal, 5-6 mm in diameter, appressed, funiculose near plug, hyaline, with an even margin. Reverse brownish orange (6C6) under plug, surrounded by greyish orange (5B3) at the margin. Hagem's: ellipsoidal, 14-21 mm in diameter, funiculoid appressed, lacunose, funiculose around plug, yellowish white (4A2), with an even margin. Reverse dark brown (6F8) under plug, surrounded by pale orange (5A3), with yellowish white (4A2) at the margin.
MICROMORPHOLOGY: Hyphae 2.0-3.9(-4.5) um in diameter, hyaline, possessing clamp connections which are doughnut-like in appearance.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (+), degradation of casamino acids (-), acidification of BCP-casamino acids agar (+), urease activity (-, growth absent), sensitive at 7°C, semi-tolerant at 30°C, semi-tolerant to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), sensitive to rose bengal (10ug/mL), sensitive to malachite green (2ug/mL), sensitive to sodium chloride (10mg/mL), polyphenol oxidase activity (tyrosinase dominant).
HABITAT: in coniferous forests under *Pinus* (Pomerleau 1980; Moser 1983; Gerhardt 1984).
ISOLATE EXAMINED: CANADA: ONTARIO: Timiskaming District, Burt Twp., 2.5 km W of Burt Lake, in plantation of *Pinus banksiana*, 23.viii.86, L.J.Hutchison UAMH 5837.
LITERATURE REPORTS OF CULTURAL CHARACTERS: Melin (1924).
REMARKS: *C.mucosus* colonies showed restricted growth on MN agar similar to that shown by *Rozites caperata*.

63. *Cortinarius subpurpurascens* (Batsch) Fr.
MACROMORPHOLOGY: BAF: irregularly circular, (6.5-)8-15 mm in diameter, felty to cottony, velvety at margin, very lacunose, often folding up upon itself and pushing parts down into the agar, white mixed with violet white (19A2), with a raised bayed to undulating even margin. Reverse brownish orange (7C5) to dull red (8C3) in centre, rest of colony dull lilac (15C3) to dull violet (16E4), with white to greyish violet (17B3) at the margin, with intense cracking of the agar below the

colony with cracks filling in with white mycelium. PDA: irregularly circular, (11-)16-22 mm in diameter, felty, velvety at margin, very lacunose, often circular depressed zones present, white in centre surrounded by violet white (19A2) to pale blue (21A3), with a raised even margin which is bayed to undulating at furrows where agar is depressed. Reverse brownish orange (6C6-7C5) to dull red (8C3) in centre, dull lilac (15C3) to dull violet (16D3) elsewhere, with white at the margin, with cracking of agar below colony often with white mycelium growing into cracks. MN: circular to irregularly circular, (6.5-)10-19 mm in diameter, felty, velvety to cottony at margin, very lacunose, folding up onto itself in places, white, violet white (19A2) to pastel violet (17A4) at a raised even margin which is bayed to undulating because of lacunose furrows where agar is depressed. Reverse brownish orange (7C5) to dull red (8C3) in centre surrounded by dull violet (16D3), with white at the margin, with the agar cracking below the colony. Hagem's: irregularly circular to irregular, (5-)8-17 mm in diameter, felty, velvety to cottony at margin, very lacunose, folding up onto itself in places, white in centre, violet white (19A2) to light violet (17A5) at a raised uneven margin which is undulating because of intense lacunose furrows where agar is depressed. Reverse greyish red (8B5) to dull red (8C3) in centre, surrounded by violet grey (16D2), with white at the margin, with intense cracking of the agar below the colony.

MICROMORPHOLOGY: Hyphae 1.6-3.2(-3.9) um in diameter, hyaline, possessing clamp connections which are doughnut-like in appearance, becoming uneven, twisted and contorted in age and possessing intercalary globose to ellipsoidal swellings 6.0-10.0 x 7.0-14.0 um.

PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (+), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (+), urease activity (-, growth absent), sensitive at 7°C, sensitive at 30°C, tolerant to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), tolerant to malachite green (2ug/mL), tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (tyrosinase dominant), DBB reaction on non-treated mycelia (negative).

HABITAT: deciduous, mixed or coniferous woods under broadleaved hosts (Lange 1938; Moser 1960; Pomerleau 1980).

ISOLATES EXAMINED: CANADA: ONTARIO: Timiskaming District, Burt Twp., Burt Lake, under Populus tremuloides and Pinus banksiana, 8.ix.82, D.W.Malloch UAMH 5940, UAMH 6195.

REMARKS: This species is distinguished by its violet coloured colonies and tendency in culture to fold up upon itself.

64. Rozites caperata (Pers.: Fr.) Karsten

MACROMORPHOLOGY: BAF: circular, 9 mm in diameter, appressed, slimy-looking with funiculose cords present, whitish, with an even margin where agar is depressed. Reverse brownish grey (4D2) in centre, surrounded by greyish yellow (4B3). PDA: slightly irregularly circular to ellipsoidal, 11-12 mm in diameter, appressed funiculose cords at centre, appressed elsewhere, whitish in centre, with an even hyaline margin. Reverse greyish beige (4C2) under plug, surrounded by yellowish white (4A2) at the margin. MN: circular, 5-6 mm in diameter, appressed, with funiculose cords on plug, whitish, with a raised even margin. Reverse beige (4C3) under plug with yellowish white (4A2) at the margin.

Hagem's: circular to slightly ellipsoidal, 16 mm in diameter, appressed, slimy-looking, lacunose, whitish, with an even margin. Reverse greyish yellow (4B3) with yellowish white (4A2) at the margin.
MICROMORPHOLOGY: Hyphae 2.0-3.9(-4.2) um in diameter, hyaline, lacking clamp connections.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (+), amylase (-), gelatinase (+), degradation of casamino acids (-), acidification of BCP-casamino acids agar (+), urease activity (variable), sensitive at 7°C, sensitive at 30°C, tolerant to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), sensitive to rose bengal (10ug/mL), semi-tolerant to malachite green (2ug/mL), sensitive to sodium chloride (10mg/mL), polyphenol oxidase activity (negative).
HABITAT: coniferous and deciduous forests throughout North America (Miller 1980; Lincoff 1981; McKnight and McKnight 1987).
ISOLATE EXAMINED: CANADA: QUEBEC: Québec Co., Quebec City, 1986, C.Godbout CRBF 545.
REMARKS: Clamp connections were absent in isolate UAMH 545, perhaps due to dedikaryotization or the possibility that the fungus is not *R.caperata*. However, it behaves like an ectomycorrhizal fungus *in vitro* (e.g. slow growth, no conidial anamorph, non-cellulolytic, non-pectinolytic). Repeated attempts to obtain a second isolate for comparison failed.

Nevolin (1963) grew this species in pure culture but noted a rapid growth similar to what would be expected of a wood-decaying fungus, suggesting that in fact it was not an actual culture of *R.caperata*.

RUSSULACEAE

Russula

Colony morphology variable but very slow growing and difficult to culture; hyphae lacking clamp connections.

65. *Russula subfoetens* W.G.Smith

MACROMORPHOLOGY: BAF: ±circular, 6-9 mm in diameter, floccose to funiculose, sometimes appearing somewhat slimy, pale grey (B1), with a raised uneven margin. Reverse brown (6E4) under plug, orange white (5A2) elsewhere. PDA: circular, 6-7 mm in diameter, densely floccose, white, sometimes pale grey (B1), with a raised even margin. Reverse light brown (6D4) under plug, yellowish white (4A2) elsewhere. MN: slightly ellipsoidal, 7-10 mm in diameter, densely floccose, white to pale grey (B1), with an appressed even hyaline margin. Reverse greyish brown (6E3) under plug, orange grey (6B2) elsewhere. Hagem's: circular to ellipsoidal, 6-9 mm in diameter, densely floccose, pale grey (B1), with a raised even margin. Reverse brownish grey (6E2) under plug, surrounded by greyish orange (6B3), with white at the margin.
MICROMORPHOLOGY: Hyphae (1.3-)1.6-2.6 um in diameter, hyaline, lacking clamp connections.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-), urease activity (-, growth absent), sensitive at 7°C, sensitive at 30°C, tolerant to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), tolerant to malachite green (2ug/mL), sensitive to sodium chloride (10mg/mL), polyphenol oxidase activity (negative), DBB reaction on non-treated

mycelia (yellow).
HABITAT: coniferous and deciduous forests (Stanis 1979).
ISOLATE EXAMINED: CANADA: NEW BRUNSWICK: Charlotte Co., St.Andrews, under Abies balsamea and Picea rubens, 30.viii.86, L.J.Hutchison UAMH 5823.
REMARKS: Species of Russula are difficult to grow in vitro. Tissue pieces from basidiomata produce fuzz but rarely grow onto the agar media. Only four species have been reported in culture: R.fragilis (Pers.: Fr.) Fr. by Melin (1924) and Hatch and Hatch (1933), R.vesca Fr. by Kowalski (1974), R.puellaris Fr. by Hatch and Hatch (1933) and R.aeruginea Lindblad: Fr. by Taylor and Alexander (1989).

66. Russula velenovskyi Melzer & Zvara

MACROMORPHOLOGY: BAF: circular, 8-15(-19) mm in diameter, appressed to slightly floccose towards centre, hyaline to whitish, with an appressed uneven margin. Reverse greyish brown (5E3) to yellowish white (4A2) in centre with whitish to hyaline at the margin. PDA: circular, (5-)14-23 mm in diameter, appressed, sometimes slimy-looking, slightly floccose towards the centre, hyaline to white, with an even margin. Reverse greyish brown (5F3) to greyish yellow (4B4) under plug, yellowish white (4A2) to hyaline elsewhere. MN: circular, (11-)15-21 mm in diameter, appressed to barely floccose, white, with an appressed uneven hyaline margin. Reverse brownish orange (6C3) to yellowish white (4A2) in centre with white to hyaline at the margin. Hagem's: circular, (9-)13-22 mm in diameter, appressed to lightly floccose towards centre, white, with an appressed uneven hyaline margin. Reverse pale red (8A3) to greyish brown (5F3) in centre, whitish to yellowish white (4A2) elsewhere.
MICROMORPHOLOGY: Hyphae 1.3-2.6 rarely up to 3.0 um in diameter, hyaline, lacking clamp connections, very rarely producing globose to ellipsoidal swellings.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-/+), urease activity (-, growth present), sensitive at 7°C, sensitive at 30°C, sensitive to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), sensitive to rose bengal (10ug/mL), sensitive to malachite green (2ug/mL), semi-tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (tyrosinase dominant), DBB reaction on non-treated mycelia (yellow).
HABITAT: associated with broad-leaved hosts in deciduous and coniferous forests (Stanis 1979; Moser 1983; Gerhardt 1984).
ISOLATES EXAMINED: CANADA: ONTARIO: Timiskaming District, Burt Twp., Burt Lake, under Betula papyrifera and Picea glauca, August 1980, D.G.Lahaie UAMH 6073, UAMH 6277.
REMARKS: Russula velenovskyi can be easily mistaken for a species of Lactarius in vitro. The mycelium of R.velenovskyi stains yellow with diazonium blue B, but cultures can be separated from the similarly yellow-staining Lactarii by their lack of laccase activity. Species of Lactarius always show laccase activity.

Lactarius

Colony morphology variable (species in section Dapetes always irregular in outline with funiculose cords prominent in centre of colonies); hyphae lacking clamp connections; gelatinase (mostly negative except for species in section Dapetes which are positive); mostly sensitive to benomyl (except some isolates in section Dapetes), sensitive to cycloheximide and malachite green; polyphenol oxidase activity (equivalent/laccase dominant).

67. **Lactarius affinis** Peck

MACROMORPHOLOGY: BAF: circular, 14-27(-35) mm in diameter, floccose, rarely appressed, light orange (6A4-6A5) to brownish orange (6C5) in centre, white or sometimes pale orange (6A3) elsewhere, with an appressed even hyaline margin. Reverse brownish orange (6C6-6C8) in centre, sometimes surrounded by greyish orange (6B6), pale orange (5A3) to orange white (5A2) at the margin. PDA: circular to irregularly circular, 10-28 mm in diameter, floccose, rarely appressed, orange white (5A2) to orange (6A6) in centre, surrounded by white, with an appressed even to uneven hyaline margin. Reverse brownish orange (5C5) to dark brown (6F8) under plug, sometimes surrounded by light orange (6A5), with light yellow (4A4-4A5) to pale orange (5A3) at the margin. MN: circular to slightly irregularly circular, 30-40(-51) mm in diameter, floccose in centre, appressed towards margin, rarely all appressed, light orange (6A5) to brownish orange (6C7-6C8) in centre, surrounded by orange (6B7), hyaline at an appressed even to uneven margin. Reverse brownish orange (6C5) to dark brown (6F8) under plug, surrounded by light orange (6A5) to orange (6B7) through to light brown (6D8), with orange white (5A2-6A2) at the margin. Hagem's: circular to slightly irregularly circular, (23-)31-43 mm in diameter, floccose to flocculose, brownish orange (6C3-6C7) to light brown (6D5) in centre, surrounded by white, sometimes greyish orange (6B6), with an appressed even to uneven hyaline margin. Reverse brown (6E8) in centre surrounded by greyish orange (6B6) to light brown (6D8), with pale orange (5A3) to yellowish white (4A2) at the margin.

MICROMORPHOLOGY: Hyphae 2.0-3.2(-3.9) rarely up to 4.5 um in diameter, hyaline, lacking clamp connections.

PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (+), urease activity (+/-, growth absent), sensitive at 7°C, sensitive at 30°C, sensitive to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), variable response to rose bengal (10ug/mL), sensitive to malachite green (2ug/mL), variable response to sodium chloride (10mg/mL), polyphenol oxidase activity (laccase dominant/ equivalent), DBB reaction on non-treated mycelia (yellow).

HABITAT: in coniferous and mixed forests, throughout North America (Miller 1980; Pomerleau 1980; Rendall 1980; McKnight and McKnight 1987).

ISOLATES EXAMINED: CANADA: NEW BRUNSWICK: Charlotte Co., St.Patrick Twp., nr Wren Lake, under Picea glauca, 23.viii.85, L.J.Hutchison UAMH 5919; St.Andrews Twp., St.Andrews, under Abies balsamea, 31.viii.86, L.J.Hutchison UAMH 5816; ONTARIO: Timiskaming District, Burt Twp., Burt Lake, under Picea glauca, August 1980, D.G.Lahaie UAMH 6078.

REMARKS: L.affinis possesses orange brown colonies which have mycelia that stain yellow with diazonium blue B. It could be confused with cultures of L.chelidonius, L.mucidus, L.rufus and L.thejogalus. However, L.chelidonius is growth tolerant at 30°C and positive for gelatin degradation.

68. *Lactarius chelidonius* Peck

MACROMORPHOLOGY: BAF: ±circular to slightly irregularly circular, (14-)17-21 mm in diameter, floccose to funiculose, orange white (5A2) in centre surrounded by pale orange (5A3) near an appressed uneven margin. Reverse brown (6E5) under plug, surrounded by greyish orange (6B5), with light orange (6A4) at the margin. PDA: irregularly circular, 12-21(-28) mm in diameter, appressed, floccose to funiculose in centre, orange white (5A2) in centre surrounded by orange (6A6), with yellowish white (4A2) at an uneven margin. Reverse brownish orange (6C8) in centre surrounded by pale orange (5A3), with yellowish white (4A2) at the margin. MN: irregularly circular, 34-37 mm in diameter, appressed, slightly floccose around plug, yellowish white (4A2) mixed with pale orange (5A3), with an ±uneven margin. Reverse greyish red (8C4) under plug, surrounded by light orange (6A4), with pale yellow (4A3) at the margin. Hagem's: irregularly circular to irregular, 31-33 mm in diameter, appressed, floccose to slightly funiculose in centre, yellowish white (3A2) surrounded by yellowish white (4A2) with tinges of orange (6B8), with an uneven margin. Reverse brown (6E8) under plug, surrounded by greyish orange (5B4) with orange white (5A2) at the margin.

MICROMORPHOLOGY: Hyphae (1.3-)2.0-3.2(-4.2) um in diameter, hyaline, lacking clamp connections.

PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (+), amylase (-), gelatinase (+), degradation of casamino acids (-), acidification of BCP-casamino acids agar (+), urease activity (+, growth absent), sensitive at 7°C, tolerant at 30°C, sensitive to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), semi-tolerant to rose bengal (10ug/mL), sensitive to malachite green (2ug/mL), sensitive to sodium chloride (10mg/mL), polyphenol oxidase activity (laccase dominant), DBB reaction on non-treated mycelia (yellow).

HABITAT: coniferous forests under *Pinus*, widely distributed in North America (Hesler and Smith 1979; Pomerleau 1980).

ISOLATE EXAMINED: CANADA: ALBERTA: 150 km N of Fort McMurray, under *Pinus banksiana*, 1976, R.M.Danielson UAMH 6197.

REMARKS: *L.chelidonius* is recognizable as a member of the section Dapetes by its degradation of gelatin. It can be separated from most other species in this section by exhibiting growth tolerance at 30°C. In section Dapetes *L.indigo* is the only other species to exhibit this character, however, *L.chelidonius* is positive for lipase activity while *L.indigo* is negative.

69. *Lactarius deliciosus* (L.: Fr.) S.F.Gray

MACROMORPHOLOGY: BAF: slightly irregularly circular to irregularly circular, (12-)27-42 mm in diameter, funiculose, sometimes floccose, reaching lid of petri dish, pale orange (6A3) to reddish orange (7A8) through to brownish orange (6C7-6C8) in centre, surrounded by yellowish white (4A2) to orange (6A7), rarely entire colony all whitish, with an appressed uneven to fimbriate hyaline margin where agar is sometimes slightly depressed, funiculose cords pale yellow (4A3). Reverse light brown (7D8) to dark brown (6F8) in centre, surrounded by orange (6B7) to brown (7E8) which is surrounded by light orange (4A4) to greyish orange (5B5-6B6), with pale yellow (4A3) to pale orange (5A3) at the margin. PDA: irregularly circular to very irregular, (10-)20-45 mm in diameter, floccose to funiculose in centre, appressed towards the margin, light orange (6A4) to brownish orange (6C8) in centre, hyaline to yellowish white (4A2) at an appressed uneven to fimbriate, slightly bayed margin, funiculose cords white to pale yellow (4A3). Reverse brown (6E8-7E8) to dark brown (6F8-7F8) in centre, surrounded by light orange (5A5-6A5) to deep orange (6A8) through to brownish orange (7C8), with pale yellow (4A3) to light orange (6A3) at the margin. MN: irregularly circular to irregular, (10-)30-44 mm in diameter, very funiculose, sometimes plumose, touching lid of petri dish, orange (6B7-6B8) to brownish orange (6C8-7C8) in centre, sometimes with tinges of deep green (25E8), with an appressed uneven to fimbriate hyaline margin, funiculose cords whitish to pale orange (5A3) often tinged with reddish orange (7A8). Reverse brown (7E8) to dark brown (6F8) in centre, surrounded by light orange (5A5) to brownish orange (6C7-7C8) sometimes with tinges of dull green (25D3), with pale yellow (4A3) to light orange (6A4-6A5) at the margin. Hagem's: slightly irregularly circular to very irregularly circular, (11-)22-35 mm in diameter, very funiculose, sometimes plumose, touching lid of petri dish, frequently deep green (25E8) to deep turquoise (24E8) or else greyish orange (6B5) to brownish orange (7B8-7C8) often with streaks of deep green (25E8) to deep turquoise (24E8), hyaline at an appressed to raised uneven ±bayed margin where agar is sometimes depressed, funiculose cords white to reddish orange (7A8). Reverse dark brown (6F8-7F8) under plug surrounded by deep green (25E8) or else orange (6A6-6B7) to brown (6E8) often with streaks of deep green (25E8), with pale yellow (4A2) to pale orange (5A3) sometimes greyish yellow (4C5) at the margin.

MICROMORPHOLOGY: Hyphae (1.6-)2.0-3.2(-3.9) um in diameter, hyaline, lacking clamp connections, occurring in funiculose strands when aerial.

PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-/+), amylase (-/+), gelatinase (+), degradation of casamino acids (-), acidification of BCP-casamino acids agar (+), urease activity (mostly +, growth absent/less commonly -, growth present), sensitive at 7°C, sensitive at 30°C, variable response to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), sensitive to semi-tolerant to malachite green (2ug/mL), sensitive to semi-tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (laccase dominant/equivalent), DBB reaction on non-treated mycelia (negative).

HABITAT: associated with conifers in coniferous and mixed woods throughout North America (Redhead 1979; Miller 1980; Rendall 1980; Lincoff 1981; McKnight and McKnight 1987).

ISOLATES EXAMINED: CANADA: ALBERTA: Rocky-Clearwater Forest, in *Pinus contorta* and *Picea mariana* bog, 28.vii.86, R.S.Currah UAMH 5449; in mixed *Picea glauca*, *P.mariana*, *Pinus contorta* woods, 3.ix.86, R.S.Currah UAMH 5547, UAMH 5548; ONTARIO: Timiskaming District, Burt Twp., Burt Lake, under *Picea glauca*, *Betula papyrifera*, *Alnus rugosa* and *Abies balsamea*, 5.ix.81, D.W.Malloch UAMH 6198; under *Picea glauca* and *Betula* sp., 26.viii.86, L.J.Hutchison UAMH 5839; NEWFOUNDLAND: Labrador, 25 km NW of Schefferville, on west side of Irony Mountain, under dwarf *Picea glauca* on mountain ledge, 28.viii.84, D.W.Malloch UAMH 6079.

LITERATURE REPORTS OF CULTURAL CHARACTERS: Melin (1924), Hatch and Hatch (1933), Mikola (1955).

REMARKS: *L.deliciosus* is readily recognizable *in vitro* as a member of section Dapetes due to its orange coloured, funiculose colonies that are irregular in outline. This placement is confirmed by the strong gelatinase activity of the cultures. In addition, half of the isolates examined were tolerant to benomyl, a tendency found only among members of the section Dapetes in Lactarius. Lactarius subpurpureus and L.thyinos are two species which are difficult to differentiate from L.deliciosus. Colonies of L.thyinos never exhibit green colouration when grown on MN and Hagem's agar while L.deliciosus and L.subpurpureus frequently do. L.subpurpureus is always associated with Tsuga canadensis while L.deliciosus has a broader host range among the conifers (Picea, Abies and Pinus).

Fuchs (1911) described L.deliciosus in culture but most likely described a contaminant as "oidia" (arthroconidia) were abundantly produced. Nevolin (1963) reported a rapid growth rate for L.deliciosus and found the rare occurence of clamp connections. While it is difficult to verify the authenticity of Nevolin's isolate, the colony morphology does not appear to fit L.deliciosus.

70. Lactarius hibbardae Peck

MACROMORPHOLOGY: BAF: circular to slightly ellipsoidal, 16-19 mm in diameter, appressed, slightly floccose to funiculose around plug, greyish orange (6B3) to greyish red (8C3), with an even hyaline margin. Reverse dark brown (6F8) to violet brown (10F8) under plug, surrounded by greyish brown (6D3) to reddish brown (9D4), with greyish orange (6B3) at the margin. Diffuse brown pigment exuding into agar and which becomes more prominent as the colony ages. PDA: circular to slightly ellipsoidal, 19-26 mm in diameter, appressed, greyish orange (6B3) to pinkish white (7A2), with an ±even hyaline at margin. Reverse dark brown (6F8) under plug, surrounded by brownish orange (6C4), with pale orange (6A3) to greyish orange (6B3) at the margin. MN: circular to ellipsoidal, 27-32 mm in diameter, appressed, sometimes becoming slightly funiculose, orange white (6A2) to greyish orange (6B3), with an even hyaline margin. Reverse dark brown (6F8) under plug, surrounded by yellowish brown (5E8) then greyish orange (6B4), with yellowish white (4A2) to orange white (6A2) at the margin. Hagem's: circular to slightly ellipsoidal, 25-30 mm in diameter, appressed to slightly floccose, often with a few funiculose cords, greyish orange (5B3) to orange white (6A2), with an even hyaline margin. Reverse dark brown (6F8) under plug, surrounded by greyish orange (6B5), with pale orange (5A3-6A3) at the margin.
MICROMORPHOLOGY: Hyphae (1.6-)2.0-3.2(-4.5) um wide, hyaline, lacking clamp connections.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-/+), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (+), urease activity (+, growth absent), sensitive at 7°C, sensitive at 30°C, sensitive to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), sensitive to rose bengal (10ug/mL), sensitive to malachite green (2ug/mL), sensitive to sodium chloride (10mg/mL), polyphenol oxidase activity (equivalent), DBB reaction on non-treated mycelia (negative).
HABITAT: under conifers in northern coniferous forests across North America (Hesler and Smith 1979; Pomerleau 1980; Rendall 1980).
ISOLATE EXAMINED: CANADA: QUEBEC: Portneuf Co., St. Augustin, under Pinus resinosa, Populus tremuloides, and Salix spp., 1981, C.Godbout CRBF 110.

71. Lactarius indigo (Schw.) Fr.
MACROMORPHOLOGY: BAF: slightly irregularly circular, 39-42 mm in diameter, floccose to funiculose in centre, appressed towards margin, lacunose, orange (6A6) in centre, surrounded by orange white (6A2) at an ±even margin. Reverse dark brown (6F8) under plug, surrounded by light orange (6A4), with yellowish white (4A2) at the margin. PDA: slightly irregularly circular to irregularly circular, 32-36 mm in diameter, extremely funiculose in centre, appressed towards margins, very lacunose, orange (6A6) in centre, with an ± even hyaline margin. Reverse greyish brown (6D3) in centre, surrounded by greyish orange (6B5), with yellowish white (4A2) at the margin. MN: slightly irregularly circular, 42-45 mm in diameter, funiculose in centre, rest of colony appressed, orange (6B8), with an ± uneven hyaline margin. Reverse dark brown (6F8) under plug surrounded by orange (6B7), with yellowish white (4A2) at the margin. Hagem's: slightly irregularly circular to irregularly circular, 42-45 mm in diameter, appressed with funiculose strands arising from surface, orange white (6A2) sometimes becoming greyish green (27E5) in centre, with an ± even margin. Reverse dark violet (17F8) under plug, orange white (6A2) elsewhere.
MICROMORPHOLOGY: Hyphae (1.6-)2.0-3.9(-4.5) um in diameter, hyaline, lacking clamp connections. Oleiferous hyphae present.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (+), degradation of casamino acids (-), acidification of BCP-casamino acids agar (+), urease activity (-/+, growth absent), sensitive at 7°C, tolerant at 30°C, sensitive to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), sensitive to malachite green (2ug/mL), sensitive to sodium chloride (10mg/mL), polyphenol oxidase activity (equivalent), DBB reaction on non-treated mycelia (red).
HABITAT: in both coniferous and deciduous woods, usually under Pinus or Quercus, eastern North America, most common in SE United States, rare northwards (Hesler and Smith 1979; Miller 1980; Lincoff 1981; Arora 1986; McKnight and McKnight 1987; Redhead 1989).
ISOLATE EXAMINED: CANADA: ONTARIO: Dufferin Co., Dufferin Co. Forest, in Pinus resinosa plantation, 15.ix.85, R.C.Summerbell UAMH 5933.
REMARKS: L. indigo is a member of the section Dapetes and is recognized as such in culture by the funiculose nature of the colonies and its liquefaction of gelatin.

72. Lactarius mucidus Burl.
MACROMORPHOLOGY: BAF: circular to slightly ellipsoidal, 13-16 mm in diameter, appressed to flocculose, greyish orange (6B5) in centre surrounded by white, with an appressed even hyaline margin. Reverse greyish orange (5B3) to greyish red (8C3) under plug surrounded by light orange (6A5) to yellowish white (4A2), with pale yellow (4A3) to hyaline at the margin. PDA: circular, 12-18 mm in diameter, appressed to flocculose, orange white (5A2) to light orange (6A5), with an appressed even to uneven hyaline margin. Reverse light orange (5A4) to greyish orange (5B4) in centre, surrounded by pale orange (5A3) to orange white (5A2) at the margin. MN: circular, 33-39 mm in diameter, floccose to sparsely woolly, brownish orange (6C8) to greyish red (8B4) in centre, orange (6A6-6A8) elsewhere, with an appressed uneven hyaline margin. Reverse brown (7D8) to dark brown (6F8) in centre, surrounded by light brown (7D8) to reddish orange (7A8), with light yellow (4A4) to hyaline

at the margin. Hagem's: irregularly circular, (19-)32-39(-47) mm in diameter, flocculose to floccose, brownish orange (6C5) in centre, surrounded by orange (6B7-6B8), with an appressed uneven to slightly bayed white to hyaline margin. Reverse brown (7E8) to brownish orange (6C8) in centre, surrounded by brownish orange (6C8) to light orange (6A4) with pale orange (6A3) to white at the margin.

MICROMORPHOLOGY: Hyphae (1.6-)2.0-3.2(-3.6) rarely up to 4.5 um in diameter, hyaline, lacking clamp connections. Hyphal coils very sparse.

PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (+), urease activity (+, growth absent), sensitive at 7°C, sensitive at 30°C, sensitive to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), sensitive to rose bengal (10ug/mL), sensitive to malachite green (2ug/mL), semi-tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (laccase dominant), DBB reaction on non-treated mycelia (yellow).

HABITAT: under conifers in coniferous and mixed woods, throughout North America (Miller 1980; Pomerleau 1980; Rendall 1980; Lincoff 1981; McKnight and McKnight 1987).

ISOLATE EXAMINED: CANADA: ONTARIO: Timiskaming District, Burt Twp., Burt Lake, in needle litter under *Picea glauca* and *Pinus banksiana*, 6.ix.81, D.W.Malloch UAMH 6076.

REMARKS: *L.mucidus* possesses orange brown colonies, does not degrade gelatin and has mycelium which stains yellow with diazonium blue B. The combination of these three characters among the Lactarii is shared only by *L.affinis*, *L.rufus* and *L.thejogalus*.

73. *Lactarius pubescens* (Schrad.) Fr.

MACROMORPHOLOGY: BAF: circular to irregularly circular, 25-29(-35) mm in diameter, floccose to funiculose, pale orange (5A3) in centre surrounded by white, with an appressed even pastel red (7A4) margin. Reverse, dark brown (7F8) under plug, surrounded by brownish orange (6C8) mixed with reddish brown (8E8), with greyish orange (6B6) at the margin. Slight pigment diffusing into the agar. PDA: slightly irregularly circular, (7-)11-15 mm in diameter, cottony to floccose in centre, white, with an appressed ±uneven light orange (6A4) margin. Reverse dark brown (6F8) under plug, surrounded by brownish orange (6C7), with orange white (5A2) at the margin. MN: slightly irregularly circular, 28-32 mm in diameter, floccose to slightly funiculose, white in centre with greyish red (7B4) to pastel red (7A4) at an appressed even margin. Reverse dark brown (7F8) under plug, surrounded by light brown (6D8) mottled with reddish brown (8E8), with brownish orange (6C6) at the margin. Hagem's: slightly irregularly circular, 19-23 mm in diameter, floccose, rarely funiculose, light orange (6A4) in centre, white to yellowish white (4A2) elsewhere, with an appressed to raised ±even margin. Reverse dark brown (7F8) under plug, surrounded by brown (7E8) mixed with brownish orange (6C7).

MICROMORPHOLOGY: Hyphae 2.0-3.9(-4.5) um in diameter, hyaline, lacking clamp connections.

PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (+), amylase (-), gelatinase (+), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-), urease activity (+, growth absent), sensitive at 7°C, semi-tolerant to 30°C, sensitive to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), semi-tolerant to rose bengal (10ug/mL),

sensitive to malachite green (2ug/mL), sensitive to sodium chloride (10mg/mL), polyphenol oxidase activity (equivalent), DBB reaction on non-treated mycelia (negative).
HABITAT: in deciduous, mixed or coniferous woods under Betula, throughout the coniferous forest zone of North America (Hesler and Smith 1979; Rendall 1980; Homola and Czapowskyj 1981; McKnight and McKnight 1987).
ISOLATE EXAMINED: CANADA: ONTARIO: Timiskaming District, Burt Twp., Burt Lake, under Betula papyrifera, Salix spp., Alnus rugosa, 1981, C.Godbout CRBF 118.
REMARKS: L.pubescens is a birch-associated Lactarius closely related to L.torminosus. Basidiomata of the two species are difficult to distinguish except by means of basidiospore size (Hesler and Smith 1979). Cultural studies also show close similarities between the two species. However, L.pubescens is positive for lipase activity but negative for amylase activity while L.torminosus is negative for lipase but strongly amylolytic.

Both species degrade gelatin similar to species within the section Dapetes. L.pubescens and L.torminosus, however, are associated with Betula while members of the section Dapetes are associated mainly with conifers.

74. **Lactarius rufus** (Scop.: Fr.) Fr.
MACROMORPHOLOGY: BAF: circular, 15-24(-32) mm in diameter, floccose to flocculose, rarely appressed, light orange (6A4) to brownish orange (7C8) through to reddish brown (8D8) in centre, white elsewhere, with an appressed even hyaline margin. Reverse brown (6E5) to dark brown (6F8-7F8) under plug, surrounded by light orange (6A4) to reddish orange (7B8), with yellowish white (4A2) to brownish orange (6C7) at the margin. PDA: circular, 11-22(-28) mm in diameter, floccose to flocculose, orange (6B6-6B8) to brown (6E8-7E8) in centre, white elsewhere, with an appressed even hyaline margin. Reverse brownish orange (6C4) to dark brown (6F8-7F8) in centre, surrounded by brownish orange (6C6) to light brown (6D8-7D8), with yellowish white (4A2) to orange white (5A2) at the margin. MN: circular to slightly irregularly circular, 10-21(-35) mm in diameter, floccose to flocculose, rarely appressed, orange (6A6-6A7) in centre, white elsewhere, with an appressed even hyaline margin. Reverse brownish orange (6C4) to brown (6E6) under plug, surrounded by pale orange (6A3) to greyish orange (6B4-6B5), with yellowish white (4A2) to pale yellow (4A3) at the margin. Hagem's: circular, 26-38 mm in diameter, floccose to flocculose, rarely funiculose, orange white (5A2) to brownish orange (6C8) in centre, white elsewhere, with an appressed even hyaline margin. Reverse brown (6E5-7E5) to dark brown (6F8) under plug, surrounded by greyish orange (6B5) to brown (6E5), yellowish white (4A2) to orange white (5A2) at the margin.
MICROMORPHOLOGY: Hyphae 2.0-3.2(-3.9) rarely up to 4.5 um in diameter, hyaline, lacking clamp connections.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-/+), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (+), urease activity (-/+, growth absent), sensitive at 7°C, sensitive at 30°C, sensitive to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), sensitive to semi-tolerant to rose bengal (10ug/mL), sensitive to malachite green (2ug/mL), semi-tolerant to

tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (equivalent), DBB reaction on non-treated mycelia (yellow).
HABITAT: under conifers in moist coniferous and mixed forests throughout North America (Hesler and Smith 1979; Redhead 1979; Miller 1980; Pomerleau 1980; Rendall 1980; Homola and Czapowskyj 1981; Lincoff 1981; McKnight and McKnight 1987).
ISOLATES EXAMINED: CANADA: NEW BRUNSWICK: Charlotte Co., 2 km NW of Lawrence Station, in *Sphagnum* under *Picea mariana* and *Larix laricina*, 4.ix.85, L.J.Hutchison UAMH 5930; ONTARIO: Timiskaming District, Burt Twp., Burt Lake, on *Pleurozium* moss under *Picea mariana*, 9.ix.82, R.C.Summerbell UAMH 6074; in needle litter beneath *Pinus banksiana*, 20.viii.86, L.J.Hutchison UAMH 5836; Norfolk Co., Delhi Twp., nr Turkey Point Provincial Park, under *Pinus strobus*, 6.x.84, L.J.Hutchison UAMH 5928; York Co., York Co. Regional Forest nr. Ballantrae, under *Larix laricina*, 12.ix.86, L.J.Hutchison UAMH 5797.
LITERATURE REPORTS OF CULTURAL CHARACTERS: Modess (1941), Mikola (1955), Pachlewski (1967) and Kowalski (1974).

75. *Lactarius subpurpureus* Peck
MACROMORPHOLOGY: BAF: circular to slightly irregularly circular, (20-) 39-47 mm in diameter, funiculose in centre, appressed elsewhere, reddish brown (8E8) to orange (6B8) in centre, orange white (6A2) to pale orange (5A3) elsewhere, with an ±even white margin. Reverse brownish orange (6C4-7C4) surrounded by pale orange (5A3-6A3), with white at the margin. PDA: circular to slightly irregularly circular, 24-33 mm in diameter, floccose to funiculose, sometimes lacunose, greyish orange (6B4) to brownish orange (7C8), with an appressed even (sometimes bayed) white to hyaline margin. Reverse brownish orange (6C7) to reddish brown (8E8) in centre, surrounded by light orange (6A4) to pastel red (7A5), with yellowish white (4A2) at the margin. MN: slightly irregularly circular to irregularly circular, 26-33 mm in diameter, very funiculose, dark brown (6F8) around plug, rest of colony light orange (6A4) to greyish orange (6B3), with a slightly funiculose to appressed even whitish margin. Reverse dark brown (6F8) to greyish brown (6E3) at centre, light orange (6A4) to pale orange (6A3) elsewhere. Hagem's: irregularly circular to irregular, (15-)25-32 mm in diameter, funiculose, dark grey (F1) to orange white (6A2) around plug, light orange (6A4) to greyish orange (6B4) elsewhere, occasionally tinges of greenish blue (24A8) appearing, with a very uneven margin. Reverse dark grey (F1) to brownish orange (6C8) in centre, surrounded by light orange (6A5) to orange white (6A2).
MICROMORPHOLOGY: Hyphae 2.0-4.5 um in diameter, hyaline, lacking clamp connections, rarely producing subglobose to ellipsoidal swellings, 6.5-9.8 x 9.1-13.6 um.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase(-), amylase (+), gelatinase (+), degradation of casamino acids (-), acidification of BCP-casamino acids agar (+), urease activity (-, growth absent), sensitive at 7°C, sensitive at 30°C, semi-tolerant to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), sensitive to malachite green (2ug/mL), sensitive to sodium chloride (10mg/mL), polyphenol oxidase activity (laccase dominant), DBB reaction on non-treated mycelia (negative).
HABITAT: in coniferous and mixed woods under *Tsuga canadensis*, eastern North America (Hesler and Smith 1979; Miller 1980; Pomerleau 1980;

Homola and Czapowskyj 1981; Lincoff 1981; McKnight and McKnight 1987).
ISOLATE EXAMINED: CANADA: ONTARIO: York Co., North York, under *Tsuga canadensis* and *Pinus strobus*, 23.ix.84, L.J.Hutchison UAMH 5926.
REMARKS: *L.subpurpureus* is recognizable as a member of the section Dapetes by the funiculose colonies, liquefaction of gelatin and degree of tolerance to benomyl.

76. *Lactarius thejogalus* (Bull.: Fr.) S.F.Gray
MACROMORPHOLOGY: BAF: circular, 18-20 mm in diameter, appressed to slightly flocculose, orange white (5A2) sometimes brownish red (8C8) in centre, with an appressed even white to hyaline margin. Reverse brownish orange (7C7) to dark brown (6F8) under plug, surrounded by orange white (6A2), with yellowish white (4A2) at the margin. PDA: circular, 18-20 mm in diameter, appressed to slightly flocculose, orange white (5A2), with an appressed even hyaline margin. Reverse greyish red (8C3) below plug, surrounded by orange white (5A2) with yellowish white (4A2) at the margin. MN: circular, 23-25 mm in diameter, appressed, cottony to floccose around plug, white in centre, surrounded by orange (6A6), with an ±even hyaline margin. Reverse brown (6E6) in centre, surrounded by pale orange (6A3) with yellowish white (4A2) at the margin. Hagem's: circular, 23-24 mm in diameter, appressed, floccose to cottony towards centre, white in centre, light orange (6A4) elsewhere, with an ±even hyaline margin. Reverse reddish grey (8C4) beneath plug, surrounded by greyish orange (6B5), with yellowish white (4A2) at the margin.
MICROMORPHOLOGY: Hyphae 2.0-3.2(-3.9) rarely up to 4.2 um in diameter, hyaline, lacking clamp connections, producing globose to ellipsoidal swellings when grown on Hagem's agar, 7.2-15.0 x 8.5-19.5 um.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-/+), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (+), urease activity (-, growth present/absent), sensitive at 7°C, sensitive at 30°C, sensitive to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), sensitive to rose bengal (10ug/mL), sensitive to malachite green (2ug/mL), sensitive to sodium chloride (10mg/mL), polyphenol oxidase activity (equivalent), DBB reaction on non-treated mycelia (yellow).
HABITAT: in moist coniferous and mixed woods in the northern conifer zone throughout North America (Hesler and Smith 1979; Redhead 1979; Pomerleau 1980; Rendall 1980).
ISOLATE EXAMINED: CANADA: NEW BRUNSWICK: Charlotte Co., St.Patrick Twp., nr Wren Lake, on rotting wood under *Abies balsamea* and *Alnus rugosa*, 23.viii.85, L.J.Hutchison UAMH 5920.
REMARKS: *L.thejogalus* possesses orange brown colonies with mycelium that stains yellow with diazonium blue B and which is negative for gelatin degradation. Only three other species of *Lactarius* possess these three characters: *L.affinis*, *L.mucidus* and *L.rufus*.

77. *Lactarius thyinos* A.H.Smith
MACROMORPHOLOGY: BAF: very irregularly circular to irregular, 14-21(-34) mm in diameter, felty to floccose to funiculose, orange (6B7-6B8) sometimes becoming brown (6E8) in centre, funiculose cords white, with an appressed uneven to irregularly bayed hyaline to light orange (6A4) margin. Reverse brownish orange (7C8) to dark brown (6F8) under plug surrounded by orange (6B8) to reddish brown (9D8), with pale yellow

(4A3) to light orange (6A4) at the margin. PDA: very irregular, (6-)13-25 mm in diameter, ± appressed, felty to funiculose in centre, light orange (6A4) to brownish orange (7C8), with yellowish white (4A2) to pale yellow (4A3) at a very uneven to irregular margin. Reverse reddish brown (9D8) to dark brown (9F8) under plug, surrounded by greyish orange (6B6) to brownish red (8C7-8C8), with yellowish white (4A2) to pale orange (6A3) at the margin. MN: irregularly circular to ellipsoidal to irregular, 12-20(-56) mm in diameter, ±appressed, slightly felty to floccose to funiculose in centre, light orange (6A5) to orange (6B7), with an uneven to irregular bayed hyaline to pale orange (6A3) margin. Reverse brown (6E8) to dark brown (9F8) under plug, surrounded by orange (6B8), with yellowish white (4A2) to orange white (6A2) at the margin. Hagem's: irregularly circular to irregular, 21-39 mm in diameter, floccose to very funiculose in centre, appressed towards margin, greyish orange (5B4-6B3), funiculose cords white, with a very uneven bayed hyaline margin. Reverse reddish brown (9E8) to dark brown (9F8) under plug, surrounded by greyish orange (6B6) to brownish orange (6C7), with yellowish white (4A2) to pale orange (5A3) at the margin.
MICROMORPHOLOGY: Hyphae 2.0-3.2(-3.9) rarely up to 4.5 um in diameter, hyaline, lacking clamp connections, commonly occurring in fascicles.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-/+), amylase (-/+), gelatinase (+), degradation of casamino acids (-), acidification of BCP-casamino acids agar (+), urease activity (-/+, growth absent), sensitive at 7°C, sensitive at 30°C, variable response to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), variable response to rose bengal (10ug/mL), sensitive to malachite green (2ug/mL), sensitive to sodium chloride (10mg/mL), polyphenol oxidase activity (equivalent), DBB reaction on non-treated mycelia (negative).
HABITAT: in woods, bogs and swamps of Thuja, eastern Canada and adjacent northeastern United States (Hesler and Smith 1979; Miller 1980; Pomerleau 1980; Rendall 1980; McKnight and McKnight 1987) associated with Abies balsamea (Rendall 1980).
ISOLATES EXAMINED: CANADA: NEW BRUNSWICK: Charlotte Co., St.Andrews Twp., St.Andrews, under Abies balsamea and Thuja occidentalis, 2.ix.85, D.W.Malloch UAMH 5939; 30.viii.86, L.J.Hutchison UAMH 5840.
REMARKS: L.thyinos is a member of the section Dapetes, recognizable by the irregularly shaped colonies which are often floccose to funiculose in the centre, the degradation of gelatin, and in one isolate the tolerance to benomyl. L.thyinos is distinguishable from other members of the group by possessing colonies which never exhibit green colouration on MN and Hagem's agar and at the same time show growth sensitivity at 30°C. L.subpurpureus and some isolates of L.deliciosus may fail to exhibit green colouration; however, L.subpurpureus is specific to Tsuga canadensis while L.thyinos is associated with Abies balsamea in Thuja bogs. Further differentiation between L.deliciosus and L.thyinos is not possible. Based upon similarities in basidiome features these two species are considered to be closely related (Hesler and Smith 1979) and not surprisingly, they have similar cultural characters. It is interesting to note that the presence or absence of green colouration of the colonies reflects the presence or absence of green staining in the basidiomata of these two species [i.e. basidiomata of L.deliciosus stain green where bruised or cut while the basidiomata of L.thyinos never stain green (Hesler and Smith 1979)].

78. *Lactarius torminosus* (Schaeff.: Fr.) S.F.Gray
MACROMORPHOLOGY: BAF: irregularly circular, 9-19(-40) mm in diameter, floccose to slightly funiculose, sometimes lacunose, brownish orange (6C8-7D8), with an appressed uneven to irregular hyaline to white margin, funiculose cords white. Reverse greyish brown (8F3) to dark brown (6F8) in centre, surrounded by brownish orange (7C8) to reddish brown (9E8), with white to pale yellow (4A3) through to orange white (5A2) at the margin. PDA: irregularly circular, 7-9/49-52 mm (depending on isolate) in diameter, appressed, slightly floccose to funiculose at plug, reddish orange (7A8-7B8) to reddish brown (8D8) in centre, surrounded by brownish orange (7C8) to orange (6B7), with an appressed uneven to irregular white to orange white (5A2) margin. Reverse brown (6E8) to dark brown (6F8) under plug, surrounded by brownish orange (6C6-6C8) to reddish brown (8D8), with white to yellowish white (4A2) at the margin. MN: irregularly circular, (9-)15-25(-48) mm in diameter, felty to floccose to funiculose, sometimes lacunose, reddish orange (7A6) to brownish orange (7C8) rarely brownish grey (7F2) in centre, light brown (6D6) to greyish orange (5B3) elsewhere, funiculose cords white, with an appressed uneven hyaline to white margin. Reverse reddish brown (8E8) to dark brown (6F8) under plug, surrounded by orange (6A6) to brownish red (8D8), with pale yellow (4A3) to orange white (5A2) at the margin. Hagem's: irregularly circular to irregular, (9-)14-23(-41) mm in diameter ±appressed, floccose to funiculose at centre, brownish orange (6C8-7C8) to greyish orange (6B4) mixed with dark brown (6F8), funiculose cords white, with an appressed uneven to irregular hyaline to white margin. Reverse brownish grey (7F2) to dark brown (6F8-8F8) under plug, surrounded by orange (6A6) to brownish orange (7C8) through to brown (7D8), with white to pale yellow (4A3) through to light orange (6A4) at the margin.
MICROMORPHOLOGY: Hyphae (1.6-)2.0-3.2(-3.9) rarely up to 4.5 um in diameter, hyaline, lacking clamp connections. Hyphal coils ± present.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (+), gelatinase (+), degradation of casamino acids (-), acidification of BCP-casamino acids agar (+), urease activity (-, growth absent), sensitive at 7°C, sensitive at 30°C, sensitive to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), variable response to rose bengal (10ug/mL), sensitive to malachite green (2ug/mL), sensitive to sodium chloride (10mg/mL), polyphenol oxidase activity (equivalent), DBB reaction on non-treated mycelia (negative).
HABITAT: in deciduous, mixed and coniferous woods under *Betula*, throughout the coniferous forest zone of North America (Hesler and Smith 1979; Miller 1980; Pomerleau 1980; Rendall 1980; Lincoff 1981; McKnight and McKnight 1987).
ISOLATES EXAMINED: CANADA: ONTARIO: Timiskaming District, Burt Twp., Burt Lake, under *Betula papyrifera*, *Alnus rugosa* and *Abies balsamea*, 3.ix.80, D.W.Malloch UAMH 6077; under *Betula* sp., *Alnus rugosa*, *Salix* sp., *Abies balsamea* and *Picea glauca*, 25.viii.86, L.J.Hutchison UAMH 5815.
REMARKS: *L.torminosus* is closely related to *L.pubescens* and can be separated from the latter species by exhibiting strong degradation of amylose but lacking the ability to degrade lipid.

79. Lactarius vinaceorufescens A.H.Smith

MACROMORPHOLOGY: BAF: circular to irregularly circular, 13-26 mm in diameter, appressed, hyaline to pale white, rarely light orange (5A3) to greyish yellow (4B3) in centre, with an even to very uneven margin. Reverse greyish yellow (4B3-4B4) to greyish orange (5B3) through to brown (6E6) under plug, surrounded by yellowish white (4A2) to pale yellow (3A3-4A3), sometimes hyaline at the margin. PDA: circular to slightly irregularly circular (rarely ellipsoidal), (7-)13-32 mm in diameter, appressed, hyaline to white, rarely yellowish white (4A2) to pale orange (5A3) in centre, with an uneven to very uneven hyaline margin. Reverse greyish yellow (4B3-4B4) to brownish orange (6C5) under plug, rest of colony yellowish white (4A2) to pale yellow (4A3). MN: ±circular, (9-)13-30(-54) mm in diameter, appressed, rarely floccose around plug, hyaline to white, rarely pale yellow (4A3) to greyish yellow (4B3) in centre, with an even to very uneven hyaline margin. Reverse greyish yellow (4B3-4C6) to greyish red (7B5-8C4) under plug surrounded by yellowish white (4A2) to orange white (5A2-6A2), sometimes with a hyaline margin. Hagem's: ±circular to rarely ellipsoidal, (16-)21-32(-42) mm in diameter, appressed, rarely flocculose at plug, hyaline to white, rarely yellowish grey (4B2) at centre, with an uneven to very uneven hyaline margin. Reverse beige (4C3) to brownish orange (5C3-7C5) under plug, surrounded by pale yellow (4A3) to orange white (5A2-6A2), with yellowish white (4A2) to hyaline at the margin.

MICROMORPHOLOGY: Hyphae (1.6-)2.0-3.6(-3.9) rarely up to 4.9 um in diameter, hyaline, lacking clamp connections. Coils rarely present.

PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (+), urease activity (variable), sensitive at 7°C, semi-tolerant to tolerant at 30°C, sensitive to benomyl (10ug/mL), semi-tolerant to tolerant (rarely sensitive) to cycloheximide (2ug/mL), sensitive (rarely tolerant) to rose bengal (10ug/mL), sensitive to malachite green (2ug/mL), variable response to sodium chloride (10mg/mL), polyphenol oxidase activity (equivalent/laccase dominant), DBB reaction on non-treated mycelia (yellow).

HABITAT: in coniferous and mixed woods particularly under Pinus, eastern Canada and adjacent northeastern United States (Hesler and Smith 1979; Rendall 1980; Homola and Czapowskyj 1981; Lincoff 1981).

ISOLATES EXAMINED: CANADA: NEW BRUNSWICK: Charlotte Co., St.Andrews Twp., St.Andrews, under Picea rubens and Abies balsamea, 30.viii.86, L.J.Hutchison UAMH 5841; ONTARIO: Timiskaming District, Burt Twp., Burt Lake, under Pinus banksiana and Betula papyrifera, 1.ix.80, D.W.Malloch UAMH 6075; under Pinus banksiana, 25.viii.83, E.Schwärtzel UAMH 6154; under Pinus banksiana and Alnus rugosa, 19.viii.86, L.J.Hutchison UAMH 5835.

REMARKS: L.vinaceorufescens is recognized in vitro by the hyaline to white, appressed colonies and consistent degree of tolerance to cycloheximide. The other twelve species of Lactarius tested were sensitive to cycloheximide.

APHYLLOPHORALES

THELEPHORACEAE

80. Thelephora terrestris Ehr.: Fr.

MACROMORPHOLOGY: BAF: very irregular, 18-36 mm in diameter, compact in growth, cerebriform grooves, sectoring at the margin, dark brown (8F8) with sectors being pale orange (6A3), with an appressed uneven margin where agar is depressed. Reverse dark brown (9F8) with greyish brown (9D4) at the margin, sectors pastel red (7A4) with pale orange (6A3) at the margin. Light pigment diffusing into the agar. PDA: irregular, usually covering plate, flocculose, dark brown (6F8) at plug, hyaline to orange white (6A2) elsewhere, with an appressed uneven (feathery) margin. Reverse dark brown (7F8) under plug, pale orange (6A3) elsewhere. MN: very irregular, 53-72 mm in diameter, flocculose, slightly lacunose, hyaline to orange white (6A2), with an appressed uneven (feathery) margin. Reverse yellowish brown (5F8) under plug, pale orange (6A3) elsewhere, sclerotia produced after two months. Hagem's: very irregular, 42-62 mm in diameter, flocculose, hyaline to pinkish white (7A2) to brown (7E8), sometimes becoming dark brown (7F8) towards centre, with an appressed uneven (feathery) margin. Reverse dark brown (8F8) in centre, pale orange (6A3) elsewhere.
MICROMORPHOLOGY: Hyphae (2.6-)4.2-7.8(-12.3) um in diameter, hyaline and lacking clamp connections or possessing pseudoclamps, sometimes several pseudoclamps at a septum, when submerged becoming twisted and contorted and rather swollen with walls invaginating at irregular intervals.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (+), amylase (-), gelatinase (+), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-), urease activity (+, growth present), sensitive at 7°C, tolerant at 30°C, tolerant to benomyl (10ug/mL), tolerant to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), semi-tolerant to malachite green (2ug/mL), sensitive to sodium chloride (10mg/mL), polyphenol oxidase activity (equivalent), DBB reaction on non-treated mycelia (negative).
HABITAT: under conifers in coniferous woods throughout North America (Corner 1968; Lincoff 1981; McKnight and McKnight 1987).
ISOLATE EXAMINED: CANADA: NEW BRUNSWICK: Charlotte Co., 2 km NW of Lawrence Station, growing in Sphagnum moss under Picea rubens and Larix laricina, 4.ix.85, L.J.Hutchison UAMH 5931.
LITERATURE REPORTS OF CULTURAL CHARACTERS: Marx et al.(1970), Miller et al. (1983).
REMARKS: T.terrestris is a distinctive fungus in culture as it degrades urea and exhibits simultaneous growth, potentially confusing it with species of Laccaria and Hebeloma. Species of these latter two genera however, possess mycelia which stain yellow with diazonium blue B.

As Marx et al. (1970) had pointed out, it is very variable morphologically. Those authors' descriptions of colony macro- and micromorphology suggest that T.terrestris may comprise a species complex. The occurrence of clamp connections was variable (Marx et al. 1970; Miller et al. 1983) and the hyphae sometimes became swollen or inflated and reached a width of 10-32 um (Miller et al. 1983).

BANKERACEAE

81. Bankera fuligineo-alba (Schmidt : Fr.) Pouz.
MACROMORPHOLOGY: BAF: irregularly circular, 13-15 mm in diameter, slimy-appressed, lacunose, yellowish white (4A2), with an uneven margin. Reverse light brown (6D8) in centre, pale orange (6A3) elsewhere, grooves visible from beneath colony. PDA: circular to slightly ellipsoidal, 15-16 mm in diameter, slimy-appressed, yellowish white (4A2), with an ±uneven margin. Reverse brownish orange (6C4) under plug, pale yellow (4A3) elsewhere. MN: ±circular to slightly irregular, 16-19 mm in diameter, slimy-appressed, lacunose with grooves in a clockwise position, yellowish white (4A2), with an ±even margin. Reverse greyish orange (6B4) in centre, orange white (5A2) elsewhere, grooves visible from below colony. Hagem's: ±circular, 21-27 mm in diameter, slimy, with cerebriform grooves, yellowish white (4A2) but with an appressed even hyaline margin. Reverse brownish orange (6C4) under plug, orange white (5A2) elsewhere.
MICROMORPHOLOGY: Hyphae 1.3-2.6(-3.2) um in diameter, hyaline, lacking clamp connections.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-/+), gelatinase (+), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-), urease activity (-, growth absent), sensitive at 7°C, semi-tolerant at 30°C, sensitive to benomyl (10ug/mL), semi-tolerant to cycloheximide (2ug/mL), sensitive to rose bengal (10ug/mL), sensitive to malachite green (2ug/mL), semi-tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (negative), DBB reaction on non-treated mycelia (negative).
HABITAT: in coniferous woods under Pinus throughout North America (Harrison 1968; Pomerleau 1980; McKnight and McKnight 1987).
ISOLATE EXAMINED: CANADA: ALBERTA: 150 km N of Fort McMurray, under Pinus banksiana, 1976, R.M.Danielson UAMH 6194.
REMARKS: B.fuligineo-alba possesses slow growing, appressed, yellowish white colonies. Superficially, it may be confused with Cortinarius mucosus and Rozites caperata, but the latter two species possess clamp connections.

POLYPORACEAE

82. Coltricia perennis (L.: Fr.) Murr.
MACROMORPHOLOGY: BAF: circular, 36-40 mm in diameter, sparsely cottony, brown (6E8), with a raised to appressed ±even margin. Reverse dark brown (6F8) surrounded by brown (6E8), with yellowish white (4A2) at the margin. PDA: circular, 30-32 mm in diameter, sparsely cottony, brown (7E8), with a raised to appressed ±uneven margin. Reverse dark brown (6F8) with light brown (6D8) at the margin. Very slight pigment being released into the agar. MN: circular, 33-34 mm in diameter, sparsely cottony, brown (7E8), with a raised to appressed ±uneven margin. Reverse dark brown (7F8) surrounded by a thin band of greyish brown (7D3) then dark brown (6F8), with brown (6E8) at the margin. Hagem's: circular, 36-38 mm in diameter, sparsely cottony, brown (6E8) with a raised to appressed ±even reddish brown (8E8) margin. Reverse dark brown (7F8) with brown (7E8) at the margin.
MICROMORPHOLOGY: Hyphae 2.0-4.2(-5.5) um in diameter, light brown, lacking clamp connections.

PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-/+), acidification of BCP-casamino acids agar (-), urease activity (-, growth present), sensitive at 7°C, tolerant at 30°C, semi-tolerant to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), sensitive to rose bengal (10ug/mL), semi-tolerant to malachite green (2ug/mL), sensitive to sodium chloride (10mg/mL), polyphenol oxidase activity (negative).
HABITAT: exposed locations in coniferous forests throughout North America (Gilbertson and Ryvarden 1986).
ISOLATE EXAMINED: CANADA: ALBERTA: Kananaskis Centre for Environmental Research, University of Calgary, under *Pinus banksiana*, 25.ix.76, R.M.Danielson CRBF 340.
LITERATURE REPORT OF CULTURAL CHARACTERS: Danielson (1984).
REMARKS: *C.perennis in vitro* possesses cottony brown colonies and a physiology similar to the Boletaceae and their gasteroid allies, thus potentially allowing confusion with *Paxillus involutus* or *Pisolithus arhizus*. However, these two latter species possess clamp connections, have non-pigmented hyphae, exude deep brown pigments into the agar (BAF and PDA) and are semi-tolerant to tolerant to sodium chloride. *C.perennis* lacks clamps, has lightly pigmented hyphae, exudes at most weak pigments into the agar, and is sensitive to sodium chloride.

Danielson (1984) reported the formation of a poroid hymenophore on the agar surface.

CORTICIACEAE

83. *Piloderma bicolor* (Peck) Jülich

MACROMORPHOLOGY: BAF: circular to slightly irregularly circular, 15-19 mm in diameter, cottony in centre, felty elsewhere, sometimes lacunose, mycelium sometimes touching lid of petri dish, yellow (3A7) to greyish yellow (3B7), with yellowish white (3A2) to white at a raised to appressed even margin where agar is sometimes depressed. Reverse dark brown (6F8-7F8) in centre, surrounded by reddish brown (8E4) to brownish orange (6C6), sometimes with thin margin of yellowish white (4A2), radial grooves visible beneath the colony when lacunose. PDA: ±circular to ±polygonal to slightly irregularly circular, 10-12 mm in diameter, flocculose to felty, sometimes lacunose, light yellow (3A5) to yellow (3A7) through to greyish yellow (3B7), with a raised to appressed even white margin where agar is slightly depressed. Reverse dark brown (8F8) to yellowish brown (5E4) in centre, surrounded by greyish red (7B3) to brownish orange (7C4), with white at the margin. Very slight pigment diffusing into the agar. MN: circular to slightly irregularly circular, (11-)18-21 mm in diameter, cottony in centre, felty elsewhere, sometimes lacunose, mycelium rarely touching lid of petri dish lid, yellow (3A7) with yellowish white (3A2) at a raised even margin where agar is sometimes slightly depressed. Reverse dark brown (7F8) to yellowish brown (5F8) in centre, surrounded by greyish red (10D5-9C5) to violet brown (10E5) through to brownish orange (7C5), with pale orange (5A3) to pale yellow (4A3) to white at the margin, radial grooves visible beneath the colony when lacunose. Sometimes very slight pigment diffusing into the agar. Hagem's: circular to slightly irregularly circular, 16-24 mm in diameter, cottony in centre, felty elsewhere, mycelium touching lid of petri dish, yellow (3A7), with a raised even yellowish white (3A2) margin. Reverse dark brown (6F8-8F8) in centre, surrounded by greyish

orange (6B5-5B4) to brownish orange (7C5) through to greyish red (8B3), with yellowish white (4A2-3A2) at the margin. Very slight pigment diffusing into agar.
MICROMORPHOLOGY: Hyphae (1.0-)1.3-2.6 rarely up to 3.2 um in diameter, hyaline, lacking clamp connections, occasionally encrusted with crytals, rarely possessing swellings when grown on PDA.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (+), degradation of casamino acids (+), acidification of BCP-casamino acids agar (+), urease activity (-, growth absent), sensitive to semi-tolerant at 7°C, sensitive to semi-tolerant at 30°C, tolerant to benomyl (10ug/mL), variable response to cycloheximide (2ug/mL), variable response to rose bengal(10ug/mL), semi-tolerant to tolerant to malachite green (2ug/mL), variable response to sodium chloride (10mg/mL), polyphenol oxidase activity (negative), DBB reaction on non-treated mycelia (yellow).
HABITAT: usually occuring as hyphal strands or rhizomorphs on ground beneath moss carpets and dead wood, associated with conifers in northern coniferous forests throughout North America (Christiansen 1960; Jülich 1972).
ISOLATES EXAMINED: SWEDEN: near Uppsala, under Picea abies, August, 1977, J.E.Nylund CBS 292.77, 293.77, 294.77.
LITERATURE REPORTS OF CULTURAL CHARACTERS: Miller et al. (1983).
REMARKS: The brilliant lemon coloured colonies on BAF, MN and Hagem's agar distinguishes this species from all others.

SCLERODERMATALES

SCLERODERMATACEAE

Scleroderma

Colonies white to yellowish white and cottony, with brown pigments diffusing into the agar (BAF and PDA); hyphae with clamp connections (except section Aculeatispora); lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-), urease (+, growth absent); tolerant at 30°C; tolerant to benomyl and malachite green; polyphenol oxidase activity (tyrosinase dominant).

84. **Scleroderma arenicola** Zeller
MACROMORPHOLOGY: BAF: ±circular, 23-27 mm in diameter, cottony, touching lid of petri dish, white, with an appressed to raised ±even margin. Reverse brownish orange (6C8) with light yellow (4A5) at the margin. Light orange pigment diffusing into the agar. PDA: circular, 27-30 mm in diameter, cottony, sometimes producing honey-coloured droplets on surface, pale yellow (2A3) with a raised ±even white margin. Reverse violet brown (10E8) in centre surrounded by a band of reddish brown (9D8), with deep orange (6A8) at the margin. Orange pigment diffusing into the agar. MN: circular to slightly irregularly circular, 37-47 mm in diameter, cottony, touching lid of petri dish, white to yellowish white (4A2), with a raised even margin. Reverse light brown (7D8) in centre, orange (6B8) elsewhere, with light yellow (3A5) at the margin. Light orange pigment diffusing into the agar. Hagem's: circular to slightly irregularly circular, 35-38 mm in diameter, cottony, almost touching lid of petri dish, white to yellowish white (4A2), with a

raised even margin. Reverse brown (7E8) in centre surrounded by orange (5A6), with pale yellow (3A3) at the margin. Very slight pigment diffusing into the agar.
MICROMORPHOLOGY: Hyphae 1.3-2.6(-3.2) rarely up to 3.9 um in diameter, hyaline, lacking clamp connections, occasionally producing swellings when submerged and grown on MN agar, globose to ellipsoidal, 10.4-14.9 x 11.7-20.8 um.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-), urease activity (+, growth absent), sensitive at 7°C, tolerant at 30°C, tolerant to benomyl (10ug/mL), tolerant to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), tolerant to malachite green (2ug/mL), semi-tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (tyrosinase dominant).
HABITAT: in coniferous and deciduous woods throughout North America (Zeller 1947; Smith 1951).
ISOLATE EXAMINED: CANADA: QUEBEC: Iberville Co., St.Gregoire, in deciduous woods, 1981, C.Godbout CRBF 106.
REMARKS: Isolates of Scleroderma species can be confused morphologically with clamped members of the Boletaceae and its allies (e.g. species of Boletinus, Paxillus and Pisolithus). The latter three genera possess species which are negative for tyrosinase activity while Scleroderma species produce tyrosinase. S.arenicola can be separated from the other two species of Scleroderma examined by its tolerance to cycloheximide.

The isolate of S.arenicola examined lacked clamp connections suggesting that dedikaryotization had taken place.

85. Scleroderma citrinum Pers.: Pers.
MACROMORPHOLOGY: BAF: circular, 21-25 mm in diameter, cottony, pale yellow (3A3) in centre, white elsewhere, with a raised even margin. Reverse brown (6E8) in centre with brownish orange (6C8) at the margin. Opaque brownish pigment forming halo around colonies. PDA: circular, 20-24 mm in diameter, cottony, pale yellow (3A3) in centre, with a raised even white margin. Reverse dark brown (9F8) surrounded by reddish brown (9E8), with deep orange (6A8) at the margin. Brown pigment diffusing into the agar. MN: circular, 27-43 mm in diameter, cottony, white to yellowish white (3A2), sometimes tinged with yellowish grey (3B2), with a raised even margin. Reverse dark brown (8F8) in centre surrounded by reddish brown (8E8), with orange (6B8) at the margin. Brown pigment diffusing into the agar. Hagem's: circular, 30-40 mm in diameter, cottony, white to yellowish white (3A2), with a raised even margin. Reverse reddish brown (8E8) surrounded by yellowish orange (4A7) at the margin. Brown pigment diffusing into the agar.
MICROMORPHOLOGY: Hyphae 2.0-4.2(-5.2) um in diameter, hyaline, possessing clamp connections with many of the clamps doughnut shaped, "paarige-type" clamps very frequent.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-), urease activity (+, growth absent), sensitive at 7°C, tolerant at 30°C, tolerant to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), sensitive to rose bengal (10ug/mL), tolerant to malachite green (2ug/mL), sensitive to sodium chloride (10mg/mL), polyphenol oxidase activity (tyrosinase dominant), DBB reaction on non-treated mycelia (yellow?).

HABITAT: in coniferous and deciduous forests throughout North America (Miller 1980; Lincoff 1981; McKnight and McKnight 1987).
ISOLATE EXAMINED: CANADA: ONTARIO: Muskoka District, Dorset, on rotting wood beneath Betula alleghaniensis and Tsuga canadensis, 22.ix.85, D.W.Malloch UAMH 5935.
LITERATURE REPORTS OF CULTURAL CHARACTERS: Masui (1927) as S.vulgare, Modess (1941) and Miller et al. (1983) as S.aurantium, and Besl et al. (1989).
REMARKS: S.citrinum can be distinguished from the other two species of Scleroderma examined by its sensitivity to rose bengal and sodium chloride.

86. Scleroderma bovista Fr.
MACROMORPHOLOGY: BAF: circular, 21-24 mm in diameter, cottony, pale yellow (3A2) with white towards a raised even margin. Reverse brownish orange (6C8). Opaque brownish orange pigment forming halo in the agar around the colony. PDA: circular, 28-29 mm in diameter, cottony, pale yellow (3A2) with white towards a raised even margin. Reverse reddish brown (8E8) in centre, surrounded by brownish orange (7C8), with orange (6B8) at the margin. Orange pigment diffusing into the agar. MN: ±circular, 20-22 mm in diameter, cottony, producing honey-coloured droplets of liquid on the surface, white, with a raised even margin. Reverse dark brown (6F8) in centre, surrounded by reddish brown (8E8), with deep orange (5A8) at the margin. Orange pigment diffusing into the agar. Hagem's: circular, 21 mm in diameter, cottony, convex, mycelium touching lid of petri dish, producing honey-coloured droplets of liquid on the surface, white, with a raised even margin. Reverse reddish brown (8E8) in centre, with yellow (3A6) at the margin. Slight pigment diffusing into the agar.
MICROMORPHOLOGY: Hyphae 1.3-2.6(-3.2) um in diameter, hyaline, lacking clamp connections, producing swellings only when submerged when grown on MN agar, globose to ellipsoidal 8.4-13.0 x 10.4-17.5 um.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-), urease activity (+/-, growth absent), sensitive at 7°C, tolerant at 30°C, tolerant to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), tolerant to malachite green (2ug/mL), semi-tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (tyrosinase dominant), DBB reaction on non-treated mycelia (negative).
HABITAT: coniferous and deciduous forests (Marx and Bryan 1969).
ISOLATE EXAMINED: CANADA: BRITISH COLUMBIA: Vancouver Island, Victoria, under Pinus contorta, 1976, J.J.Dennis UAMH 6202.
LITERATURE REPORTS OF CULTURAL CHARACTERS: Marx and Bryan (1969).
REMARKS: S.bovista can be distinguished from the other species of Scleroderma examined in this study by possessing both sensitivity to cycloheximide and semi-tolerance to sodium chloride.

The isolate examined in this present study lacked clamp connections probably due to dedikaryotization. Marx and Bryan (1969) reported clamp connections in their isolates. They also noted great variability in growth rates between the isolates.

87. *Pisolithus arhizus* (Scop.: Pers.) Rausch. [syn. *P.tinctorius* (Mich.: Pers.) Coker & Couch]
MACROMORPHOLOGY: BAF: circular, (13-)18-28 mm in diameter, cottony to compact cottony, mycelium frequently touching lid of petri dish, brown (6E5) to dark brown (6F8-8F8), sometimes surrounded by reddish brown (8D6-8E5) to dark brown (8F8), with a raised even margin where agar is slightly depressed. Reverse dark brown (8F8) to brown (7E8) in centre, with brownish orange (6C8-7C7) at the margin. Intense orange to brownish orange opaque pigment forming halo in the agar around the colony. PDA: circular to slightly ellipsoidal, 27-28 mm in diameter, cottony to compact cottony, sometimes floccose, mycelium rarely touching lid of petri dish, reddish brown (8E8) to dark brown (7F8), with a raised (rarely appressed) ±even margin. Revese dark brown (6F8-8F8) with brownish orange (6C6-7C8) at the margin, with the agar sometimes cracking under centre of the colony. Orange pigment diffusing into the agar. MN: circular to slightly irregularly circular, (27-)36-45(-51) mm in diameter, cottony, mycelium touching lid of petri dish, brown (6E8-7E8) to dark brown (6F5), with a raised ±even margin. Reverse black to dark ruby (12F8) in centre, surrounded by violet brown (10E8-10F8), with brownish orange (6C6-6C8) at the margin. Orange pigment diffusing into the agar. Hagem's: circular to slightly ellipsoidal, 35-50 mm in diameter, cottony, mycelium touching lid of petri dish, greyish brown (6D3) to brown (6E6-7E6), sometimes with light brown (6D5) at a raised ±even to uneven margin. Reverse greyish brown (7F3) to violet brown (11F8) in centre, surrounded by reddish brown (9E8) to violet brown (10F8), with brownish orange (6C6-6C8) at the margin. Light pigment sometimes diffusing into the agar.
MICROMORPHOLOGY: Hyphae (2.0-)2.6-5.2(-5.8) um in diameter, hyaline, possessing clamp connections which are frequently doughnut-shaped, producing swellings only when submerged when grown on PDA.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-), urease activity (+, growth absent), sensitive at 7°C, tolerant at 30°C, tolerant to benomyl (10ug/mL), tolerant to cycloheximide (2ug/mL), sensitive to rose bengal (10ug/mL), tolerant to malachite green (2ug/mL), semi-tolerant to tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (negative), DBB reaction on non-treated mycelia (negative).
HABITAT: usually in dry disturbed sites with broad range of coniferous and deciduous hosts, common in SE United States and Pacific coast region, rare elsewhere (Grand 1976; Marx 1977).
ISOLATES EXAMINED: CANADA: ONTARIO: Muskoka District, Gibson Twp., nr Go Home Lake, on granite outcrop under *Pinus strobus* and *Quercus rubra*, R.G.Thorn UAMH 6272, UAMH 6273; QUEBEC: Québec Co., Québec, with *Pinus strobus* seedlings in greenhouse, 1986, C.Godbout CRBF 519; FRANCE: Arcachon Landes, under *Pinus pinaster*, 1976, D.Mousain UAMH 6199.
LITERATURE REPORTS OF CULTURAL CHARACTERS: Hile and Hennen (1969), Miller *et al*. (1983), Besl *et al*. (1989), van der Westhuizen and Eicker (1989).
REMARKS: *P.arhizus* is a distinctive species in culture (brown, cottony colonies with clamp connections on hyphae) and is likely to be confused only with *Paxillus involutus*. While *P.involutus* is unable to degrade urea (exhibits growth), *P.arhizus* is positive for urea degradation (without growth). In addition, the growth of *P.arhizus* is not inhibited

when grown on lipase test agar unlike that of *P.involutus* which has a much reduced growth rate.

Kope and Fortin (1990) reported *P.arhizus* as possessing a tetrapolar heterothallic mating system. They also suggested that based on incompatibility reactions between certain monokaryons as well as on basidiospore morphology, *P.arhizus* possibly comprises at least three biological species.

Dennis (1980) and Grenville *et al*. (1985a) discussed the production of sclerotia in association with seedlings.

HYMENOGASTRALES

RHIZOPOGONACEAE

Rhizopogon

Colonies cottony to appressed cottony or felty, radially lacunose, whitish, with dark brown pigments diffusing into the agar (BAF and PDA); hyphae lacking clamp connections; lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-), urease (mostly -, growth present); tolerant to benomyl and malachite green, mostly sensitive to sodium chloride; polyphenol oxidase activity (tyrosinase dominant/negative); diazonium blue B reaction on non-treated mycelia (negative).

88. *Rhizopogon rubescens* (Tul.) Tul.

MACROMORPHOLOGY: BAF: ± polygonal, 38-55 mm in diameter, sparsely cottony to felty, radially lacunose, white to light grey (C1-D1) in centre, with brownish grey (6C2) to pale grey (B1) at a raised even margin where agar is sometimes depressed. Reverse brown (6E7-7E8), with radial grooves visible from below the colony. Light brown to orange opaque pigment forming halo in the agar around the colony. PDA: polygonal to slightly irregularly circular, (21-)43-57 mm in diameter, felty, radially lacunose, often producing dark droplets in centre, white to greyish beige (4C2) in centre below droplets, sometimes surrounded by brownish grey (6C2), with a ±raised even white margin. Reverse dark brown (8F8) to violet brown (10F8) in centre, surrounded by reddish brown (8D8-8E8), sometimes brownish orange (6C8) to yellowish white (4A2) at the margin, with radial grooves visible beneath the colony. Brown pigment diffusing into the agar. MN: circular, 47-62 mm in diameter, cottony to felty, radially lacunose, white to greyish yellow (4B3) surrounded by reddish brown (9E5), with greyish brown (8D3) to brownish red (8C6) at a ±raised even to uneven margin. Reverse dark brown (8F8) in centre, surrounded by reddish brown (8E8), with brownish orange (7C8) to reddish orange (7B8) at the margin, with radial grooves visible beneath the colony, agar sometimes cracking below the colony. Brown pigment diffusing into the agar. Hagem's: circular, 46-72 mm in diameter, cottony to floccose, radially lacunose, white sometimes becoming yellowish white (3A2) in centre, occasionally greyish red (7B6) at a raised even margin. Reverse reddish brown (9E8) sometimes greyish brown (5D3) in centre, surrounded by brownish orange (6C8-7C8), with orange white (5A2) at the margin, with radial grooves visible beneath the colony which may result in cracking of the agar.

MICROMORPHOLOGY: Hyphae (1.3-)2.0-3.9(-4.5) rarely up to 5.2 um in diameter, hyaline, lacking clamp connections, rarely producing

intercalary swellings on PDA, globose to ellipsoidal 13.0-17.5 x 14.3-22.8 um.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-), urease activity (-, growth present/absent), sensitive at 7°C, tolerant at 30°C, tolerant to benomyl (10ug/mL), semi-tolerant to tolerant to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), semi-tolerant to tolerant to malachite green (2ug/mL), sensitive to sodium chloride (10mg/mL), polyphenol oxidase activity (tyrosinase dominant), DBB reaction on non-treated mycelia (negative).
HABITAT: in coniferous forests, under *Pinus* (particularly two-needled species) throughout North America (Smith and Zeller 1966; Miller 1980).
ISOLATES EXAMINED: CANADA: ALBERTA: Slave Lake Forest, in mixed *Pinus contorta* and *Picea glauca* woods, 5.ix.85, R.S.Currah UAMH 5190; ONTARIO: Timiskaming District, Burt Twp., Burt Lake, in plantation of *Pinus banksiana*, 29.viii.83, E.Schwärtzel UAMH 6157.
LITERATURE REPORTS OF CULTURAL CHARACTERS: Miller *et al*. (1983), Chu-Chou and Grace (1984).
REMARKS: *R*.*rubescens*, like most species of *Rhizopogon* tested, is differentiated from species of *Suillus* by its sensitivity to sodium chloride. *Xerocomus* species, which are also sensitive to sodium chloride, differ from most *Rhizopogon* species by degrading urea (with absence of growth), by producing cottony colonies and by exhibiting growth sensitivity at 30°C. Most *Rhizopogon* species are unable to degrade urea (growth), have appressed, cottony, radially lacunose colonies and are generally tolerant in growth at 30°C.

R.*rubescens* can be differentiated from *R*.*vinicolor* by producing tyrosinase and being growth tolerant at 30°C while the latter species is negative for tyrosinase and is growth sensitive at 30°C. *R*.*rubescens* cannot be further differentiated from *R*.*superiorensis* and *R*.*vulgaris* using the cultural characters presented in this study. *R*.*rubescens* is more common and has a broader geographic range than either *R*.*vulgaris* or *R*.*superiorensis*.

89. *Rhizopogon superiorensis* A.H.Smith

MACROMORPHOLOGY: BAF: circular to slightly irregularly circular, 35-46 mm in diameter, cottony to appressed cottony, radially lacunose, white, with a raised even margin. Reverse brown (6E5) in centre surrounded by dark brown (8E8) at the margin, with the agar cracking below centre of the colony. Intense brownish orange opaque pigment forming halo in the agar around the colony. PDA: circular to slightly irregularly circular, 34-37 mm in diameter, compact cottony, circularly lacunose, white, with an appressed to raised even margin. Reverse dark grey (F1) in centre surrounded by violet brown (10E8), with orange (6B8) at the margin. Orange pigment diffusing into the agar. MN: circular, 45-54 mm in diameter, appressed cottony, lacunose in centre, white in centre, surrounded by beige (4C3) then dark grey (F1), with brownish orange (7C4) at a raised ±even margin where agar is slightly depressed. Reverse medium grey (E1) in centre, surrounded by dark grey (F1) then violet brown (10E8), with reddish orange (7B8) at the margin, where the agar is slightly cracking in the centre. Dark orange pigment diffusing into the agar. Hagem's: circular, 61-66 mm in diameter, sparsely appressed cottony to cottony, radially lacunose in centre, whitish, with a raised even margin. Reverse brown (7E4) surrounded by brownish red

(10D8) then surrounded by orange (6B7), with pale yellow (4A3) at the margin, with radial grooves visible from beneath the colony resulting in cracking of agar below centre.
MICROMORPHOLOGY: Hyphae (1.3-)2.0-3.2(-3.9) rarely up to 4.8 um in diameter, hyaline, lacking clamp connections, only rarely producing a few swellings when submerged and only when grown on MN agar.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-), urease activity (variable), sensitive at 7°C, tolerant at 30°C, tolerant to benomyl (10ug/mL), tolerant to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), tolerant to malachite green (2ug/mL), sensitive to sodium chloride (10mg/mL), polyphenol oxidase activity (tyrosinase dominant), DBB reaction on non-treated mycelia (negative).
HABITAT: in coniferous forests under Pinus resinosa, Great Lakes region of eastern North America (Smith 1966).
ISOLATE EXAMINED: CANADA: ONTARIO: Timiskaming District, Burt Twp., Burt Lake, under Pinus resinosa, Picea glauca, 1981, C.Godbout CRBF 104.
REMARKS: R.superiorensis cannot be differentiated from R.rubescens or R.vulgaris based on the present in vitro characters used in this study. It possesses a restricted geographic range compared to the more common R.rubescens which is widespread throughout North America.

90. Rhizopogon vinicolor A.H.Smith
MACROMORPHOLOGY: BAF: circular to slightly irregularly circular, 35-39 mm in diameter, felty, radially lacunose, greyish yellow (4B5) with white towards an appressed to raised ±even margin. Reverse light brown (7D8) to brown (7E8). Intense brownish orange pigment forming halo in the agar around the colony. PDA: circular to slightly irregularly circular, 33-40 mm in diameter, felty, radially lacunose, pale yellow (4A3) in centre, greyish yellow (4B3) towards an appressed to raised even margin. Reverse dark brown (6F8) in centre surrounded by reddish brown (8D8), with deep orange (6A8) at the margin, with radial grooves visible below the colony. Orange pigment diffusing into the agar. MN: circular to slightly irregularly circular, 32-36 mm in diameter, felty, Y-shaped radial grooves present, greyish yellow (4B4), with an appressed to raised even white margin. Reverse dark brown (9F8) in centre, surrounded by reddish brown (9E8) with deep orange (6A8) at the margin, with radial grooves visible beneath the colony. Orange pigment diffusing into the agar. Hagem's: circular, 38-42 mm in diameter, felty, radially lacunose, greyish yellow (4B4) in centre with greyish beige (4C2) at an appressed to raised even margin. Reverse reddish brown (8E8) with orange (5A7) at the margin, with radial grooves visible from below the colony. Light orange pigment diffusing into the agar.
MICROMORPHOLOGY: Hyphae (1.3-)1.6-3.2(-3.9) um in diameter, hyaline, lacking clamp connections.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-), urease activity (-, growth present), sensitive at 7°C, sensitive at 30°C, tolerant to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), sensitive to rose bengal (10ug/mL), tolerant to malachite green (2ug/mL), sensitive to sodium chloride (10mg/mL), polyphenol oxidase activity (negative), DBB reaction on non-treated mycelia (negative).

HABITAT: in coniferous forests under *Pseudotsuga menziesii* in western North America (Smith and Zeller 1966; Molina and Trappe 1982).
ISOLATE EXAMINED: USA: OREGON: Benton Co., under *Pseutotsuga menziesii* and *Tsuga heterophylla*, 1975, R.Molina and J.Trappe UAMH 6200.
REMARKS: *R.vinicolor* is easily distinguishable from the other three species of *Rhizopogon* examined during this study by its growth sensitivity at 30°C, sensitivity to cycloheximide and testing negative for tyrosinase. The other three species were growth tolerant at 30°C, cycloheximide tolerant and possessed tyrosinase activity.

91. *Rhizopogon vulgaris* (Vitt.) M.Lange

MACROMORPHOLOGY: BAF: ±circular, 53-70 mm in diameter, appressed cottony to felty, radially lacunose, yellowish grey (4B2) in centre, surrounded by medium grey (E1), white elsewhere, with a raised even greyish red (8C4) margin. Reverse dark brown (6F8). Brownish orange pigment diffusing into the agar. PDA: ±circular, 43-55 mm in diameter, sparsely cottony to velvety, radially lacunose, producing black droplets on surface at centre, light brown (6D7) at plug, whitish elsewhere, with greyish red (7B3) at an appressed to raised even margin. Reverse dark brown (8F8) in centre, surrounded by reddish brown (8E8) then brownish orange (6C8), with pale yellow (4A3) at the margin. Orange pigment diffusing into the agar. MN: circular, 62-67 mm in diameter, sparsely cottony becoming felty in the centre, whitish, with a raised uneven margin. Reverse dark brown (8F8) in centre surrounded by reddish brown (8E8), with brownish orange (7C8) at the margin. Brownish orange pigment diffusing into the agar. Hagem's: ±circular, 69-80 mm in diameter, cottony, white with tinges of yellowish white (4A2), with a raised ±uneven margin. Reverse dark brown (7F8) in centre, surrounded by reddish brown (9E8), greyish orange (6B6) elsewhere, with pale yellow (4A3) at the margin.
MICROMORPHOLOGY: Hyphae (1.3-)1.6-3.2(-4.5) um in diameter, hyaline, lacking clamp connections.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-), urease activity (-, growth present), sensitive at 7°C, tolerant at 30°C, tolerant to benomyl (10ug/mL), tolerant to cycloheximide (2ug/mL), sensitive to rose bengal (10ug/mL), tolerant to malachite green (2ug/mL), semi-tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (tyrosinase dominant), DBB reaction on non-treated mycelia (negative).
HABITAT: under conifers in coniferous woods, mainly restricted in distribution in North America to the Pacific NW of the United States and adjacent Canada (Smith and Zeller 1966; Smith *et al*. 1981) but may also be found elsewhere.
ISOLATE EXAMINED: SOUTH AFRICA: under *Pinus radiata*, 1982, UAMH 6201.
REMARKS: *R.vulgaris* is indistinguishable from *R.rubescens* and *R.superiorensis* based on *in vitro* characters. *R.rubescens* is the commonest species found and is widespread across North America while both *R.vulgaris* and *R.superiorensis* are restricted in distribution and are rare (Smith *et al*. 1981).

92. *Alpova diplophloeus* (Zeller & Dodge) Trappe & A.H.Smith

MACROMORPHOLOGY: BAF: ±circular to slightly irregularly circular, (13-)40-47(-64) mm in diameter, matted to felty to appressed woolly, sometimes cottony, very lacunose, sometimes producing dark droplets at centre, greyish brown (7E3) to reddish brown (8E6) in centre, with orange grey (6B2) to yellowish grey (4B2) at a raised to appressed rarely bayed ±even margin where agar is sometimes slightly depressed. Reverse black to dark brown (7F8) in centre, surrounded by violet brown (10F8), with brownish orange (6C6-7C8) at the margin, where radial grooves are sometimes visible beneath the colony. Orange to orange brown pigment diffusing into the agar. PDA: circular to slightly irregularly circular, (13-)33-44(-77) mm in diameter, cottony, felty to matted, often lacunose in centre, often producing black droplets in centre, greyish yellow (4C5) to greyish brown (5D3) through to yellowish brown (5E4) in centre, with reddish brown (9E7) to dark brown (6F8) at a raised to appressed (rarely submerged) even to uneven margin. Reverse black to dark ruby (12F8) in centre, with reddish brown (9D6) at the margin. Reddish brown to orange brown pigment diffusing into the agar. MN: circular, 59-77 mm in diameter, cottony to felty, rarely lacunose, brown (6E8) to greyish orange (6B3) around plug, greyish brown (5E3) to greyish yellow (4B3) elsewhere, with a raised to appressed even to ±uneven margin. Reverse dark brown (6F8) in centre, surrounded by reddish brown (9D6), with brownish orange (6C6) to yellowish brown (5D5) at the margin, with radial grooves visible from below colony when lacunose, slight orange pigment diffusing into the agar. Hagem's: circular to slightly irregularly circular (rarely polygonal), (28-)57-80 mm in diameter in 5 weeks, cottony to rarely cottony-felty, slightly lacunose, yellowish white (4A2) to greyish yellow (4B3) mixed with greyish brown (5E3-7D3), with a raised even to uneven rarely bayed margin. Reverse dark brown (6F8-8F8) to violet brown (10F8) in centre, surrounded by violet brown (10E8) to brown (6E8), with greyish orange (5B3) to brownish orange (6C6) at the margin, with radial grooves rarely visible beneath the colony. Very light orange pigment rarely diffusing into the agar.

MICROMORPHOLOGY: Hyphae (1.3-)2.0-3.2(-3.9) rarely up to 5.2 um in diameter, hyaline, possessing clamp connections which often are doughnut-shaped.

PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (+), acidification of BCP-casamino acids agar (-), urease activity (+/-, growth absent), sensitive at 7°C, sensitive at 30°C, tolerant to benomyl (10ug/mL), variable response to cycloheximide (2ug/mL), variable response to rose bengal (10ug/mL), tolerant to malachite green (2ug/mL), sensitive to sodium chloride (10mg/mL), polyphenol oxidase activity (equivalent), DBB reaction on non-treated mycelia (negative).

HABITAT: under *Alnus* in moist sites throughout the range of *Alnus* in North America (Trappe 1975).

ISOLATES EXAMINED: CANADA: QUEBEC: under *Alnus crispa*, 1981, C.Godbout UAMH 6192; Mistassini Territory?, Baie James, under *Alnus crispa*, 28.viii.83, B.J.McAfee CRBF 306; USA: OREGON: under *Alnus rubra*, R.Molina UAMH 6193.

REMARKS: *A.diplophloeus* can be distinguished from other boletaceous fungi with clamp connections by its consistent production of laccase when grown on modified Hagem's agar as well as by its degradation of casamino acids. The boletes and their gasteroid relatives never produce laccase and none of the clamped species degrade casamino acids. *A.diplophloeus* can be further differentiated from *Pisolithus*, *Paxillus*, Boletinus and most Scleroderma species by exhibiting extreme sensitivity to sodium chloride.

Isolate CRBF 306 lacked clamp connections indicating that it had become dedikaryotized.

93. Truncocolumella citrina Zeller

MACROMORPHOLOGY: BAF: irregularly circular, 32-34 mm in diameter, appressed, funiculose in centre, lacunose, reddish brown (9E4), with an even margin. Reverse violet brown (10F8) with brownish red (8C6) at the margin, with radial grooves faintly visible from beneath the colony. Orange brown pigment diffusing into the agar. PDA: slightly irregularly circular, 27-34 mm in diameter, somewhat funiculose in centre, appressed elsewhere, lacunose, reddish brown (8E5), with an even margin. Reverse dark brown (8F8) with brownish red (8C6) at the margin. Orange brown pigment diffusing into the agar. MN: circular, 19-33 mm in diameter, cottony to flocculose in centre, rest of colony appressed, finely lacunose, light brown (6D5) surrounded by reddish brown (8E5), with an even greyish brown (8D3) margin. Reverse violet brown (10F8) with reddish orange (7B7) at the margin, with radial grooves faintly visible from below the colony. Very faint pigment diffusing into the agar. Hagem's: ±circular to slightly irregularly circular, 31-34 mm in diameter, cottony to felty in centre, appressed towards margin, radially lacunose, greyish brown (7D3) surrounded by reddish brown (8E6), with an even greyish brown (8D3) margin. Reverse dark brown (9F8) in centre, surrounded by reddish brown (9E8), with reddish orange (7B7) at margin, with radial grooves visible from below the colony. Yellowish brown pigment diffusing into the agar.
MICROMORPHOLOGY: Hyphae (1.3-)2.0-3.2(-3.9) um in diameter, hyaline, lacking clamp connections.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-/+), acidification of BCP-casamino acids agar (-), urease activity (-, growth absent), sensitive at 7°C, sensitive at 30°C, tolerant to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), sensitive to rose bengal (10ug/mL), semi-tolerant to malachite green (2ug/mL), sensitive to sodium chloride (10mg/mL), polyphenol oxidase activity (tyrosinase dominant), DBB reaction on non-treated mycelia (negative/yellow).
HABITAT: in coniferous forests under Pseudotsuga menziesii in western North America (Miller 1980; Lincoff 1981; Smith et al. 1981; McKnight and McKnight 1987).
ISOLATE EXAMINED: USA: MONTANA: Mission Resevoir, under Pseudotsuga menziesii and Abies grandis, 1987, O.K.Miller UAMH 6163.
REMARKS: T.citrina could potentially be confused with species of Rhizopogon. However, the ±appressed colonies which are reddish brown in colour distinguish it from species of Rhizopogon which tend to be cottony to felty and whitish.

ELASMOMYCETACEAE

94. Zelleromyces gilkeyae Singer & A.H.Smith

MACROMORPHOLOGY: BAF: slightly irregularly circular, 35-46 mm in diameter, felty to appressed woolly, lacunose, sometimes producing droplets of golden coloured liquid on surface, beige (4C3) to greyish brown (5D3) in centre, with white towards a ±raised even margin where

agar is slightly depressed. Reverse dark brown (6F8) to reddish brown (8E8), with orange (5B7) at the margin, with radial grooves visible beneath the colony. Orange pigment diffusing into the agar below the colony. PDA: circular to slightly irregularly circular, 38-40 mm in diameter, felty, radially lacunose only in centre, producing black droplets around plug, greyish brown (5E3) with patches of greyish orange (5B3) in centre, pale grey (B1) at a ±raised even margin. Reverse black to dark ruby (12F8) in centre, surrounded by a thin band of violet brown (10E8), with reddish orange (7B7) at the margin. Reddish orange pigment diffusing into the agar. MN: circular, 37-40 mm in diameter, felty to ±appressed woolly, lacunose, producing clear droplets on the surface, dull white mixed with patches of pale grey (B1) and greyish yellow (4B3), with a ±raised even margin. Reverse dark brown (7F8) surrounded by greyish orange (6B6), with pale yellow (4A3) at the margin, with radial grooves visible from below the colony. Very slight orange pigment diffusing into the agar. Hagem's: slightly irregularly circular, 26-31(-43) mm in diameter, felty to appressed woolly, lacunose, dull white mixed with patches of pale grey (B1) and greyish yellow (4B3), with a raised even margin where agar is ±depressed. Reverse mottling of reddish brown (9D4) with greyish red (8B6), with deep orange (6A8) to pale yellow (4A3) at the margin, with radial grooves visible beneath the colony. Very slight orange pigment sometimes diffusing into the agar.
MICROMORPHOLOGY: Hyphae 1.3-2.3(-2.6) um in diameter, hyaline, lacking clamp connections.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (-), acidification of BCP-casamino acids agar (-), urease activity (-, growth absent), semi-tolerant at 7°C, sensitive at 30°C, tolerant to benomyl (10ug/mL), tolerant to cycloheximide (2ug/mL), semi-tolerant to rose bengal (10ug/mL), sensitive to malachite green (2ug/mL), sensitive to sodium chloride (10mg/mL), polyphenol oxidase activity (equivalent/laccase dominant).
HABITAT: in coniferous forests under _Pseudotsuga menziesii_, western North America (Molina and Trappe 1982).
ISOLATE EXAMINED: USA: WASHINGTON: Cowlitz Co., under _Pseudotsuga menziesii_, _Alnus rubra_ and _Tsuga heterophylla_, 1976, R.Molina ATCC 46166.
REMARKS: While _Zelleromyces_ is considered to be related to the genus _Lactarius_ (Thiers 1984), this isolate of _Z.gilkeyae_ bore little resemblance _in vitro_ to this genus. It resembled more closely the genus _Rhizopogon_. Perhaps this isolate has been mislabelled and a culture of _Rhizopogon_ was distributed as a _Zelleromyces_. Nevertheless, ATCC 46166 could be differentiated from the four species of _Rhizopogon_ examined by producing laccase in addition to tyrosinase, and being sensitive to malachite green. The _Rhizopogon_ species tested never produced laccase and were always tolerant to malachite green.

HYDNANGIACEAE

95. _Hydnangium carneum_ Wallr.

MACROMORPHOLOGY: BAF: circular, 23-24 mm in diameter, floccose to flocculose around plug, rest of colony sparsely flocculose, appressed towards margin, white in centre, hyaline elsewhere, with an appressed to

submerged ±even margin. Reverse dark brown (7F8) under plug, surrounded by greyish orange (6B3), hyaline at the margin. PDA: circular, 25-26 mm in diameter, floccose in centre, flocculose to appressed elsewhere, whitish in centre, greyish yellow (4B3) elsewhere, with an appressed uneven (fimbriate) hyaline margin. Reverse yellowish brown (5F8) under plug, surrounded by thin band of yellowish brown (5D5), with yellowish white (4A2) elsewhere. MN: circular, 32-33 mm in diameter, appressed, a little flocculose around plug, light brown (6D7) in centre, surrounded by white with an ±even hyaline margin. Reverse light brown (6D4) in centre, orange white (5A3) elsewhere. Hagem's: circular, 35-37 mm in diameter, cottony to floccose at centre around plug, appressed elsewhere, white in centre, with an ±even hyaline margin. Reverse brownish red (8C6) under plug, surrounded by yellowish white (4A2) at the margin.
MICROMORPHOLOGY: Hyphae 2.0-2.6(-3.2) um in diameter, hyaline, possessing clamp connections some of which are doughnut-shaped, producing swellings when grown on PDA and MN agar, globose to ellipsoidal, 8.5-13.0 x 9.8-19.5 um. Hyphal coils present, 40-60 um in diameter.
PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-), amylase (-), gelatinase (-), degradation of casamino acids (+), acidification of BCP-casamino acids agar (-), urease activity (-, growth absent), sensitive at 7°C, semi-tolerant at 30°C, tolerant to benomyl (10ug/mL), sensitive to cycloheximide (2ug/mL), sensitive to rose bengal (10ug/mL), sensitive to malachite green (2ug/mL), semi-tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (tyrosinase dominant), DBB reaction on non-treated mycelia (yellow).
HABITAT: under Eucalyptus (Chu-Chou and Grace 1981b), California, Oregon and southeastern states of USA where hosts have been introduced.
ISOLATE EXAMINED: USA: OREGON: in plantation of Eucalyptus globulus, 1978, R.Molina UAMH 6196.
REMARKS: H.carneum may be mistaken in vitro for isolates of Laccaria. However, it can be differentiated by exhibiting sensitivity to both cycloheximide and rose bengal and by not degrading urea. Laccaria species are tolerant to both cycloheximide and rose bengal and degrade urea (with growth exhibited on urease test agar).

The presence of hyphal coils have previously been reported by Moore et al. (1989) who found them on the surface of the mantle of ectomycorrhizae synthesized between H.carneum and Eucalyptus pilularis.

MYCELIA STERILIA

96. Cenococcum geophilum Fr.: Fr. [syn. C.graniforme (Sow.) Ferd. & Winge]

MACROMORPHOLOGY: BAF: circular to ellipsoidal, 25-39 mm in diameter, felty, black, sometimes tinged with white in age, with a submerged uneven margin. Black in reverse. PDA: circular to ellipsoidal, 15-36 mm in diameter, appressed to felty, black, sometimes tinged with white in age, with submerged uneven margin. Black in reverse. MN: circular to ellipsoidal, 23-38 mm in diameter, felty, black, sometimes tinged with white in age, with a submerged uneven margin. Black in reverse. Hagem's: circular to ellipsoidal, 29-37 mm in diameter, felty, black, sometimes tinged with white in age, with a submerged uneven margin. Black in reverse.

MICROMORPHOLOGY: Hyphae (1.6-)2.6-4.5(-5.5) um in diameter, brown, sometimes hyaline, with simple septa, frequently encrusted with granules, occasionally producing a few ellipsoidal swellings (5.2-11.0 x 7.8-13.0 um), but quite rare.

PHYSIOLOGICAL AND BIOCHEMICAL CHARACTERS: lipase (-/+), amylase (+), gelatinase (-), degradation of casamino acids (-/+), acidification of BCP-casamino acids agar (-), urease activity (variable), sensitive at 7°C, sensitive to semi-tolerant at 30°C, sensitive to benomyl (10ug/mL), tolerant to cycloheximide (2ug/mL), tolerant to rose bengal (10ug/mL), semi-tolerant to tolerant to malachite green (2ug/mL), sensitive to semi-tolerant to sodium chloride (10mg/mL), polyphenol oxidase activity (laccase dominant?).

HABITAT: broad host and geographic range throughout North America (Trappe 1964).

ISOLATES EXAMINED: CANADA: ONTARIO: Timiskaming District, Burt Twp., Burt Lake, isolated from mycorrhizal root of unknown tree species, 24.viii.80, D.G.Lahaie UAMH 6146; isolated from mycorrhizal root of Picea mariana, 10.ix.82, R.C.Summerbell UAMH 6080; QUEBEC: isolated from mycorrhizal root of Picea mariana, 1967, C.Richard UAMH 6145.

LITERATURE REPORTS OF CULTURAL CHARACTERS: Hatch (1934) as Mycelium radicis nigrostrigosum, Lihnell (1942), Mikola (1948), Park (1970), Miller et al. (1983).

REMARKS: C.geophilum is distinquished in vitro by the jet black colour of the colonies and felty appearance. Older colonies become tinged with white as noted by Hatch (1934) and Mikola (1948). Mikola found that sclerotia were sometimes produced in vitro. Trappe (1969) reported that it was easier to obtain cultures of C.geophilum from sclerotia than from ectomycorrhizae.

The sensitivity of C.geophilum to 1 ug/mL benomyl incorporated into isolation media indicates the ascomycetous affinities of this fungus. Most Ascomycetes are highly sensitive to benomyl at low concentrations, unlike Basidiomycetes (Bollen and Fuchs, 1970). Trappe (1971) had shown through transmission electron microscopy that C.geophilum had a simple pore at the septum and suggested that it was related to the ascomycetous genus Elaphomyces. Lobuglio et al. (1990) recently showed that comparisons of rDNA profiles revealed no relationships between Cenococcum and Elaphomyces.

DISCUSSION

The system of agaric taxonomy as outlined by Singer (1986) appears to be supported by cultural characters as far as ectomycorrhizal species are concerned. Certain key characters in particular, such as clamp connections, benomyl sensitivity, laccase activity, etc., have consistently been found among species within any given genus and thus have a high value for predicting behaviour among untested members of these genera. This indicates how valuable these taxonomic characters could be for determining the generic identity of taxa isolated from field-collected ectomycorrhizae, especially for species not examined in this present study.

In addition to generic delimitation, certain subgeneric groups can be recognized employing these cultural characters. Section Dapetes of the genus Lactarius can be differentiated in vitro from other groups within the Lactarii by the degradation of gelatin (Hutchison 1990a), inclination towards exhibiting growth tolerance to benomyl (10ug/mL) (Hutchison 1990c) and very funiculose colonies which are irregular in outline. Similarly, within *Tricholoma*, two sections of the subgenus Tricholoma can be differentiated from each other: section Tricholoma is strongly positive for laccase activity while section Genuina is negative to weakly positive (Hutchison 1990b).

Not all characters are equally useful for delimiting genera. For example, benomyl (10ug/mL) is a very useful character for defining *Hebeloma* (growth sensitive) and the boletes (growth tolerant) but is not very useful for species of *Amanita* and *Tricholoma* whose species vary in their responses. Likewise the diazonium blue B staining reaction of non KOH pre-treated mycelia showed how a character could be important for certain genera but not for others. Cortinarii (7 species) were negative while species of *Laccaria* (4 species) and *Hebeloma* (5 species) stained yellow. However, within the large genera *Lactarius* and *Suillus*, three different staining responses to diazonium blue B were observed, consistent for each species but varying between species.

A number of cultural characters directly corresponded to characters found in basidiomata. This was especially true with regards to the presence or absence of clamp connections, as per Nobles' Rule: if basidiomata have clamps, so too will their respective cultures. It was equally true that laccase and tyrosinase activity in cultures (Hutchison 1990b) directly corresponded to such activity in basidiomata (Marr *et al*. 1986). And lastly, colony colours may often be a reflection of the colours of the basidiomata (e.g. violet colours in colonies of *Laccaria bicolor* reflecting the violet coloured mycelia at the base of the stipe in basidiomata or the green tinges observed in colonies of *Lactarius deliciosus* but not *L.thyinos*, reflecting the presence of green staining in the basidiomata of the former but not in those of the latter). Agerer (1988) suggested a correlation between colour of ectomycorrhizae formed by particular species and the colour of mycelia at the base of the stipe of basidiomata, while Oort (1981) had suggested a correlation between culture colour of *Lactarius subpurpureus* and basidiomata colour.

In some cases, cultural characters assist greatly in the resolution of existing taxonomic problems. For example species placed the genus *Fuscoboletinus* by Pomerleau and Smith (1962) (e.g. *S.glandulosus*, *S.ochraceoroseus*, *S.sinuspaulianus*, *S.spectabilis* and *S.viscidus*) were indistinguishable *in vitro* from typical *Suillus* species morphologically and physiologically. Thus cultural data supports Singer's (1986) placing *Fuscoboletinus* in synonymy with *Suillus*.

However, the long-standing argument among Agaricologists over the validity of *Boletinus* was not entirely resolved using cultural studies. Many authors place *Boletinus* species into either *Suillus* or *Fuscoboletinus* (e.g. Smith and Thiers 1971) while Singer (1986) regards *Boletinus* as distinct. Sutara (1987) persuasively argued for the separate status of *Boletinus* by demonstrating that a predominant part of the stipe surface in *Suillus* is covered with a caulohymenium whereas *Boletinus* possesses a sterile stipe. More recently, Samson and Fortin (1988) synthesized ectomycorrhizae between *Larix laricina* and species of *Suillus* and *Fuscoboletinus* sensu Smith and Thiers (1971) and found that two distinct mycorrhizal morphology types were formed. Interestingly, when Singer's (1986) taxonomic system is applied to the two groups of species involved, those fungi in Samson and Fortin's group 1 correspond to species of Boletinus and Suillus (section Solidipedes subsection Spectabiles) while group 2 includes other species of Suillus (section Glandulosi and Larigni). Except for the consistent presence of clamp connections, found only in Boletinus, cultural data from the present study does not provide support for Singer's view on the distinctive nature of Boletinus vis-à-vis Suillus.

The gasteromycetous fungi are polyphyletic [i.e. thought to have evolved independently from various groups within the Agaricales (e.g. Heim 1971)]. Singer's (1986) dissenting view is that the Agaricales evolved from gasteroid fungi. It has been suggested that certain direct links exist between specific genera within the Agaricales and specific genera within the Gasteromycetes (Smith 1973; Miller 1983; Thiers 1984). These reduced relatives of the agarics have commonly been referred to as being "secotioid". Evidence to support direct relationships include spore morphology and tissue type (Thiers 1984), the sharing of similar fungal parasites (Heim 1971), and more recently a comparison of mitochondial DNA (Bruns et al. 1989). Cultural studies support many of the proposed relationships. Rhizopogon and Truncocolumella, the presumed secotioid counterparts of members of the Boletaceae (Heim 1971; Smith 1973; Thiers 1984), share similarities for most characters examined in this study (e.g. growth tolerance to benomyl, lack of laccase activity, brown pigments diffusing into the agar). The cultural characters of Rhizopogon are almost identical to Suillus supporting the recent molecular evidence of Bruns et al. (1989) that the two genera are indeed closely related. Similar relationships have been proposed for Hydnangium with Laccaria and Zelleromyces with Lactarius (Thiers 1984). While the former two appeared to be physiologically and morphologically similar in most respects, the latter two genera bore less resemblance to each other.

Pisolithus and Scleroderma (Sclerodermataceae) which are not secotioid, have been suggested as being related to the Agaricaceae (=Agaricales s.str.) (Jülich, 1981) while Gill and Watling (1986) indicated a relationship with the Boletaceae based on similarity of fungal pigments. Similarity of in vitro characters (Hutchison 1990a, 1990b, 1990c, 1990d) between the Boletaceae and the Sclerodermataceae indicates a taxonomic relationship. The Sclerodermataceae are probably related to the Boletaceae through a common ancestor, but this split would have occurred before the evolution of the Rhizopogonaceae (Rhizopogon and Truncocolumella) and the Boletaceae. Absence of clamp connections is considered to be an advanced character and thus their presence in most species of the Sclerodermataceae suggests that they evolved much earlier from the ancestral "bolete" than the more recently evolved Rhizopogonaceae. Just how closely related the Sclerodermataceae is to the boletes compared with the Rhizopogonaceae might be answered through DNA analysis. Dissimilarity in basidiospore morphology need not be used as an argument against linking both groups together. The basidiospores of Strobilomyces species for example are as different from the majority of the boletes as are basidiospores of Scleroderma and Pisolithus. The bolete parasite Apiocrea chrysosperma (Tul.) Sydow also occurs on Scleroderma species (Arnold, 1976). This parasite is specific to members of the Boletaceae and closely related allies (e.g. Paxillus, Rhizopogon) suggesting a taxonomic relationship.

In addition to examining taxonomic relatedness, information obtained from the various in vitro physiological and biochemical characters employed in this paper also reflects ecological similarity among various (often unrelated) taxa. For example, while Laccaria and Hebeloma species are found in two totally unrelated families (Tricholomataceae and Cortinariaceae respectively), they shared most of the key cultural characters employed. Both share the same ecological niche in nature by being early stage colonizers of tree seedlings (Last et al. 1987) which impart upon them the sharing of many physiological and ecological attributes that later stage colonizers might not possess. Likewise, growth sensitivity or tolerance to 30°C appears to be correlated with host associations in nature. Those fungi specific to hosts of xerophytic habitats (e.g. Pinus and Quercus) shared the characteristic of growth tolerance at 30°C while those fungi specific to hosts which prefer cool, moist soils (e.g. Picea, Alnus or Larix) tended to be sensitive at 30°C (Hutchison 1990d).

Further cultural studies still need to be done to compare and resolve relationships among many of the higher fungi, both ectomycorrhizal and saprophytic species. This contribution hopefully will be viewed as a starting point for future investigations.

ACKNOWLEDGEMENTS

Drs. Randy Currah and Lynne Sigler (UAMH), Renée Fortier (CRBF), Drs. Hugues Massicotte and Larry Peterson (University of Guelph), Drs. David Malloch and Greg Thorn (University of Toronto), Dr. Orson K. Miller (Virginia Polytechnic Institute) and J.J. Dennis (Forestry Canada, Victoria) kindly sent me cultures. Ellen Schwärtzel, Jitka Lom, Dr. Richard C. Summerbell, Ignazio Carbone, Dr. Janusz Zwiazek, Dr. T. Sawa, Karl Wimmi, Dr. Jack Dainty and Les Radvanyi translated several critical papers. Financial support was provided by a Natural Sciences and Engineering Research Council of Canada (NSERC) postgraduate scholarship and by an NSERC operating grant (A0145) to Dr. David Malloch in whose laboratory this work was undertaken.

LITERATURE CITED

Agerer, R. 1987. Colour atlas of ectomycorrhizae. Einhorn-Verlag Eduard Dietenberger, Schwäbisch Gmünd, Federal Republic of Germany.

------- 1988. Studies on ectomycorrhizae. XIV. Mycorrhizae formed by Cortinarius hercynicus and C.variecolor on Picea abies. Can. J. Bot. 66: 2068-2078.

Arnold, G.R.W. 1976. Internationale bibliographie der Hypomycetaceae. Bibl. Mitt. Universitätbibl. Jena 25: 1-129.

Arora, D. 1986. Mushrooms demystified. 2nd ed. Ten Speed Press, Berkeley, California.

Besl, H., Bresinsky, A., Golla, I. 1989. Die Bestimmung von Mycelien mykorrhizabildender Arten der Boletales (Basidiomycetes). Int. J. Mycol. Lichenol. 4: 161-179.

Bird, C.J., and Grund, D.W. 1979. Nova Scotian species of Hygrophorus. Proc. N.S. Inst. Sci. 29: 1-131.

Boidin, J. 1971. Nuclear behaviour in the mycelium and the evolution of the Basidiomycetes. In Evolution in the higher Basidiomycetes. Edited by R.H.Petersen. The University of Tennessee Press, Knoxville.

pp. 129-144.

Bollen, G.J., and Fuchs, A. 1970. On the specificity of the in vitro and in vivo antifungal activity of benomyl. Neth. J. Pl. Path. 76: 299-312.

Bruchet, G. 1970. Contribution à l'étude du genre Hebeloma (Fr.) Kummer; partie spéciale. Bull. Soc. Linn. Lyon 39 suppl.: 1-132.

Bruns, T.D., Fogel, R., White, T.J., and Palmer, J.D. 1989. Accelerated evolution of a false-truffle from a mushroom ancestor. Nature 339: 140-142.

Campbell, M.P., and Petersen, R.H. 1975. Cultural characters of certain Amanita taxa. Mycotaxon 1: 239-258.

Christiansen, M.P. 1960. Danish resupinate fungi Part II. Homobasidiomycetes. Dansk Bot. Ark. 19(2): 57-388.

Chu-Chou, M. 1979. Mycorrhizal fungi of Pinus radiata in New Zealand. Soil Biol. Biochem. 11: 557-563.

Chu-Chou, M., and Grace, L.J. 1981a. Mycorrhizal fungi of Pseudotsuga menziesii in the North Island of New Zealand. Soil Biol. Biochem. 13: 247-249.

------- and -------. 1981b. Hydnangium carneum, a mycorrhizal fungus of Eucalyptus in New Zealand. Trans. Br. mycol. Soc. 77: 650-651.

------- and -------. 1982. Mycorrhizal fungi of Eucalyptus in the North Island of New Zealand. Soil Biol. Biochem. 14: 133-137.

------- and -------. 1983a. Characterization and identification of mycorrhizas of radiata pine in New Zealand. Aust. For. Res. 13: 121-132.

------- and -------. 1983b. Characterization and identification of mycorrhizas of Douglas fir in New Zealand. Eur. J. For. Path. 13: 251-260.

------- and -------. 1984. Cultural characteristics of Rhizopogon spp. associated with Pinus radiata seedlings. N. Z. Jour. Bot. 22: 35-41.

------- and -------. 1987. Mycorrhizal fungi of Pseudotsuga menziesii in the South Island of New Zealand. Soil Biol. Biochem. 19: 243-246.

------- and -------. 1988. Mycorrhizal fungi of radiata pine in different forests of the North and South Islands in New Zealand. Soil Biol. Biochem. 20: 883-886.

Corner, E.J.H. 1968. A monograph of Thelephora (Basidiomycetes). Beih. Nova Hedwigia 27: 1-110.

Danielson, R.M. 1984. Ectomycorrhizal associations in jack pine stands in northeastern Alberta. Can. J. Bot. 62: 932-939.

Danielson, R.M., and Pruden, M. 1989. The ectomycorrhizal status of urban spruce. Mycologia 81: 335-341.

Davidson, R.W., Campbell, W.A., and Vaughn, D.B. 1942. Fungi causing decay of living oaks in the eastern United States and their cultural identification. USDA Tech. Bull. No. 785.

Dennis, J.J. 1980. Sclerotia of the Gasteromycete Pisolithus tinctorius. Can. J. Microbiol. 26: 1505-1507.

Dickhardt, R. 1985. Homokaryotisierung von Basidiomyceten. Bibliotheca Mycologica 95: 1-136.

Dominik, T. 1969. Key to ectotrophic mycorrhizae. Folia Forestalia Polonica ser. A. 15: 309-321.

Donk, M.A. 1964. A conspectus of the families of Aphyllophoralles. Persoonia 3: 199-324.

Fox, F.M. 1986. Ultrastructure and infectivity of sclerotia of the ectomycorrhizal fungus Paxillus involutus on birch (Betula spp.)

Trans. Br. mycol. Soc. 87: 627-631.

Fries, N. 1985. Intersterility groups in Paxillus involutus. Mycotaxon 24: 403-409.

Fries, N., and Mueller, G.M. 1984. Incompatibility systems, cultural features and species circumscriptions in the ectomycorrhizal genus Laccaria (Agaricales). Mycologia 76: 633-642.

Fries, N., and Neumann, W. 1990. Sexual incompatibility in Suillus luteus and S.granulatus. Mycol. Res. 94: 64-70.

Fuchs, J. 1911. Ueber die beziehungen von Agaricineen und anderen humusbewohnenden Pilzen zur Mycorhizenbildung der Waldbäume. Bibl. Bot. 18: 1-32.

Gerhardt, E. 1984. Pilze band 1. BLV Verlagsgesellschaft mBH, Munich.

Gilbertson, R.L., and Ryvarden, L. 1986. North American polypores Vol.1. Fungiflora, Oslo.

Gill, M., and Watling, R. 1986. The relationship of Pisolithus (Sclerodermataceae) to other fleshy fungi with particular reference to the occurrence and taxonomic significance of hydroxylated pulvinic acids. Pl. Syst. Evol. 154: 225-236.

Giltrap, N.J. 1981. Formation of primordia and immature fruiting bodies by ectomycorrhizal fungi in culture. Trans. Br. mycol. Soc. 77: 204-205.

Gnutenko, M.P., and Pankova, L.A. 1955. Cultures of mycorrhiza-forming fungi with oak roots and their effect on the development of seedlings. In Mycotrophy in plants. Edited by A.A. Imshenetskii. Academy of Sciences of the U.S.S.R., Institute of Microbiology, Moscow (English translation 1967). pp. 344-347.

Grand, L.F. 1976. Distribution, plant associates and variation in basidiocarps of Pisolithus tinctorius in the United States. Mycologia 68: 672-678.

Grenville, D.J., R.L.Peterson and Y.Piché. 1985a. The development, structure, and histochemistry of sclerotia of ectomycorrhizal fungi. I. Pisolithus tinctorius. Can. J. Bot. 63: 1402-1411.

-------, ------- and -------. 1985b. The development, structure, and histochemistry of sclerotia of ectomycorrhizal fungi. II. Paxillus involutus. Can. J. Bot. 63: 1412-1417.

Grund, D.W., and Harrison, K.A. 1976. Nova Scotian boletes. Bibliotheca Mycologica 47: 1-283.

Harrison, K.A. 1968. Studies on the hydnums of Michigan. 1. Genera Phellodon, Bankera, Hydnellum. Mich. Bot. 7: 212-264.

Hatch, A.B. 1934. A jet-black mycelium forming ectotrophic mycorrhizae. Sv. Bot. Tidskr. 28: 369-383.

Hatch, A.B., and Hatch, C.T. 1933. Some Hymenomycetes forming mycorrhizae with Pinus strobus L. Jour. Arnold Arb. 14: 324-333.

Haug, I., Kottke, I., and Oberwinkler, F. 1986. Licht- und elektronenmikroskopische Untersuchung von Mykorrhizen der Fichte (Picea abies L.(Karst.)) in Vertikalprofilen. Z. Mykol. 52: 373-392.

Haug, I., and Oberwinkler, F. 1987. Some distinctive types of spruce mycorrhizae. Trees 1: 172-188.

Hawksworth, D.L., Sutton, B.C., and Ainsworth, G.C. 1983. Dictionary of the Fungi. 7th ed. Commonwealth Mycological Institute, Kew.

Heim, R. 1971. The interrelationships between the Agaricales and Gasteromycetes. In Evolution in the higher Basidiomycetes. Edited by R.H.Peterson. University of Tennessee Press, Knoxville. pp. 505-534.

Hesler, L.R., and Smith, A.H. 1963. North American species of Hygrophorus. University of Tennessee Press, Knoxville.

------- and -------. 1979. North American species of Lactarius. University of Michigan Press, Ann Arbor.

Hile, N., and Hennen, J.F. 1969. In vitro culture of Pisolithus tinctorius mycelium. Mycologia 61: 195-198.

Homola, R.L., and Czapowskyj, M.M. 1981. Ectomycorrhizae of Maine 2. A listing of Lactarius with the associated hosts (with additonal information on edibility). Maine Agric. Exp. Sta. Bull. No. 779.

Homola, R.L., Czapowskuj, M.M., and Blum, B.M. 1985. Ectomycorrhizae of Maine 3. A listing of Hygrophorus with the associated hosts (with additional information on edibility). Maine Agric. Exp. Sta. Bull. No. 810.

Homola, R.L., and Mistretta, P.A. 1977. Ectomycorrhizae of Maine 1. A listing of Boletaceae with the associated hosts. Maine Agric. Exp. Sta. Bull. No. 735.

How, J.E. 1940. The mycorrhizal relations of larch I. A study of Boletus elegans Schum. in pure culture. Ann. Bot. n.s. 4: 135-150.

-------. 1942. The mycorrhizal relations of larch III. Mycorrhiza formation in nature. Ann. Bot. n.s. 6: 103-129.

Hutchison, L.J. 1989. The absence of conidia as a morphological character in ectomycorrhizal fungi. Mycologia 81: 587-594.

-------. 1990a. Studies on the systematics of ectomycorrhizal fungi in axenic culture. II. The enzymatic degradation of selected carbon and nitrogen compounds. Can. J. Bot. 68: 1522-1530.

-------. 1990b. Studies on the systematics of ectomycorrhizal fungi in axenic culture. III. Patterns of polyphenol oxidase activity. Mycologia 82: 424-435.

-------. 1990c. Studies on the systematics of ectomycorrhizal fungi in axenic culture. IV. The effect of some selected fungitoxic compounds upon linear growth. Can. J. Bot. 68: 2172-2178.

-------. 1990d. Studies on the systematics of ectomycorrhizal fungi in axenic culture. V. Linear growth response to standard extreme temperatures used as a taxonomic character. Can. J. Bot. 68: 2179-2184.

Hutchison, L.J., and Malloch, D.W. 1988. A verification protocol for cultural isolates of ectomycorrhizal Basidiomycetes. In Canadian Workshop on Mycorrhizae in Forestry. Edited by M.Lalonde and Y.Piché. Université Laval, Sainte Foy, Québec. pp. 121-124.

Hutchison, L.J., and Summerbell, R.C. 1990. Studies on the systematics of ectomycorrhizal fungi in axenic culture. Reactions of mycelia to diazonium blue B staining. Mycologia 82: 36-42.

Jenkins, D.T., and Petersen, R.H. 1976. A neotype specimen for Amanita muscaria. Mycologia 68: 463-469.

Jülich, W. 1972. Monographie der Athelieae (Corticiaceae, Basidiomycetes). Willdenowia Beih. 7: 1-283.

-------. 1981. Higher taxa of Basidiomycetes. Bibliotheca Mycologica 85: 1-485.

Käärik, A., and Rennerfelt, E. 1957. Investigations on the fungal flora of spruce and pine stumps. Meddr. St. Skogsf. Inst. 47: 1-88.

Khudyakov, Y.P., and Voznyakovskaya, V.M. 1951. Pure cultures of mycorrhizal fungi. Mikrobiologiya 20: 13-19.

Kornerup, A., and Wanscher, J.H. 1978. Methuen handbook of colour. 3rd ed. Methuen Ltd., London.

Kowalski, S. 1974. Zbiorowiska grzybow lesnego srodowiska glebowego wybranych drzewostanow sosnowych. Prace Kom. Nauk Roln. Les (PTPN, Wydz. Nauk Roln. Les.) 38: 123-165.

Kope, H.H., and Fortin, J.A. 1990. Germination and comparative morphology of basidiospores of Pisolithus arhizus. Mycologia 82: 350-357.

Kropp, B.R., and Fortin, J.A. 1988. The incompatibility system and relative ectomycorrhizal performance of monokaryons and reconstituted dikaryons of Laccaria bicolor. Can. J. Bot. 66: 289-294.

Lahaie, D.G. 1981. The genus Laccaria in the boreal forest of eastern Canada. M.Sc. thesis, University of Toronto.

Laiho, O. 1970. Paxillus involutus as a mycorrhizal symbiont of forest trees. Acta For. Fenn. 106: 1-65.

Lamb, R.J., and Richards, B.N. 1970. Some mycorrhizal fungi of Pinus radiata and P.elliottii var. elliottii in Australia. Trans. Br. mycol. Soc. 54: 371-378.

Lange, J.E. 1938. Flora Agaricina Danica Vol. III. Society for the Advancement of Mycology in Denmark and the Danish Botanical Society, Copenhagen.

Largent, D., Johnson, D., and Watling, R. 1977. How to identify mushrooms to genus III: microscopic features. Mad River Press, Inc., Eureka, California.

Last, F.T., Dighton, J., and Mason, P.A. 1987. Successions of sheathing mycorrhizal fungi. Trends Ecol. Evol. 2: 157-161.

Laut, J.G. 1966. Cultural characteristics of three species of Boletinus. Can. J. Bot. 44: 395-402.

Lihnell, D. 1942. Cenococcum graniforme als Mykorrizabildner von Waldbäumen. Symb. Bot. Upsal. 5(2): 1-19.

Lincoff, G.H. 1981. The Audubon Society field guide to North American mushrooms. Alfred A. Knopf, Inc., New York.

Lobuglio, K.F., Rogers, S.O., and Wang, C.J.K. 1990. The Cenococcum geophilum - Elaphomyces connection. MSA Newsletter 41: 26

McArdle, R.E. 1931. Determining the identity of mycorrhiza-forming fungi. Papers Mich. Acad. Sci., Arts and Letters 13: 159-164.

McKnight, K.H., and McKnight, V.B. 1987. A field guide to mushrooms of North America. Houghton Mifflin Co., Boston.

Malloch, D. 1974. Tricholoma fulvum. Fungi Canadenses No. 31.

Malloch, D.W., Pirozynski, K.A., and Raven, P.H. 1980. Ecological and evolutionary significance of mycorrhizal symbioses in vascular plants (A review). Proc. Natl. Acad. Sci. USA 77: 2113-2118.

Marr, C.D., Grund, D.W., and Harrison, K.A. 1986. The taxonomic potential of laccase and tyrosinase spot tests. Mycologia 78: 169-184.

Marx, D.H. 1969. The influence of ectotrophic mycorrhizal fungi on the resistance of pine roots to pathogenic infections. I. Antagonism of mycorrhizal fungi to root pathogenic fungi and soil bacteria. Phytopathology 59: 153-163.

-------. 1977. Tree host range and world distribution of the ectomycorrhizal fungus Pisolithus tinctorius. Can. J. Microbiol. 23: 217-223.

Marx, D.H., and Bryan, W.C. 1969. Scleroderma bovista, an ectomycorrhizal fungus of pecan. Phytopathology 59: 1128-1132.

Marx, D.H., Bryan, W.C., and Grand, L.F. 1970. Colonization, isolation, and cultural descriptions of Thelephora terrestris and other ectomycorrhizal fungi of shortleaf pine seedlings grown in fumigated soil. Can. J. Bot. 48: 207-211.

Masui, K. 1927. A study of the ectotrophic mycorrhizas of woody plants. Mem. Coll. Sci., Kyoto Imp. Univ., Ser. B., 3: 149-279.

Melin, E. 1922. Untersuchungen über die Larix-Mykorrhiza I. Synthese der Mykorrhiza in Reinkultur. Sv. Bot. Tidskr. 16: 161-196.

-------. 1923a. Experimentelle Untersuchungen über die Konstitution und Okologie der Mykorrhizen von Pinus sylvestris L. und Picea abies (L.) Karst. Mykol. Unters. Ber. 2: 72-331.

-------. 1923b. Experimentelle Untersuchungen über die Birken-und Espenmykorrhizen und ihre Pilzsymbioten. Sv. Bot. Tidskr. 17: 479-520.

-------. 1924. Zur Kenntnis der Mykorrhizapilze von Pinus montana. Bot. Not. (1924) : 69-92.

Mikola, P. 1948. On the physiology and ecology of Cenococcum graniforme. Comm. Inst. For. Fenn. 36(3): 1-104.

-------. 1955. Metsämaan kantasienien puhdasviljely. Karstenia 3: 5-16.

Miller, O.K. 1980. Mushrooms of North America. E.P. Dutton Publishing Co., Inc., New York.

-------. 1983. Ectomycorrhizae in the Agaricales and Gasteromycetes. Can. J. Bot. 61: 909-916.

Miller, O.K., Miller, S.L., and Palmer, J.G. 1983. Description and identification of selected mycorrhizal fungi in pure culture. Mycotaxon 18: 457-481.

Modess, O. 1941. Zur Kenntnis der Mykorrhizabildner von Kiefer und Fichte. Symb. Bot. Upsal. 5(1): 1-146.

Molina, R., and Trappe, J.M. 1982. Patterns of ectomycorrhizal host specificity and potential among Pacific Northwest conifers and fungi. Forest Sci. 28: 423-458.

Moore, A.E.P., Massicotte, H.B., and Peterson, R.L. 1989. Ectomycorrhiza formation between Eucalyptus pilularis Sm. and Hydnangium carneum Wallr. in Dietr. New Phytol. 112: 193-204.

Mosca, A.M.L., and Fontana, A. 1965. Sulla coltura di miceli isolati da micorrize 1. Boletus luteus L. Allionia 11: 63-71.

Moser, M. 1960. Die gattung Phlegmacium (Schleimköpfe). J.Klinkhardt, Bad Helbrunn, Austria.

-------. 1983. Keys to agarics and boleti. Roger Phillips, London.

Mueller, G.M. 1982. The genus Laccaria in North America excluding Mexico. Ph.D. thesis, University of Tennessee.

Nevolin, O.A. 1963. The study of mycorrhizal fungi of wood species in pure culture. Lesn. Zh. Arkangel'sk 6(2): 13-21. (Transl. Israel Progr. for Sci. Transl., Jerusalem, 1966).

Nobles, M.K. 1948. Studies in forest pathology VI. Identification of cultures of wood-rotting fungi. Can. J. Res., Sect. C. 26: 281-431.

-------. 1971. Cultural characters as a guide to the taxonomy of the Polyporaceae. In Evolution in the higher Basidiomycetes. Edited by R.H.Petersen. The University of Tennessee Press, Knoxville. pp. 169-196.

Oort, A.J.P. 1981. Nutritional requirements of Lactarius species and cultural characters in relation to taxonomy. North-Holland Publishing Co., Amsterdam.

Orton, P.D. 1987. Notes on some agarics from Scotland. Notes RBG Edinb. 44: 485-502.

Ovrebo, C.L. 1980. A taxonomic study of the genus *Tricholoma* (Agaricales) in the Great Lakes Region. Ph.D. thesis, University of Toronto.

-------. 1989. *Tricholoma*, subgenus *Tricholoma*, section *Albidogrisea*: North American species found principally in the Great Lakes region. Can. J. Bot. 67: 3134-3152.

Ovrebo, C.L., and Smith, A.H. 1979. Studies on *Tricholoma vaccinum* and *Tricholoma imbricatum* in North America. Mich. Bot. 18: 99-106.

Pachlewski, R. 1967. Investigations of pure culture of mycorrhizal fungi of pine (*Pinus silvestris* L.) Forest Research Institute, Warsaw.

Palm, M.E., and Stewart, E.L. 1984. *Suillus neoalbidipes*: a new species for *Suillus albidipes*. Mycologia 76: 433-438.

Pantidou, M.E. 1961. Cultural studies of Boletaceae. *Gyrodon merulioides* and four species of *Boletinus*. Can. J. Bot. 39: 1149-1162.

-------. 1964. Cultural studies of Boletaceae: Carpophores of *Xerocomus badius* and *Xerocomus illudens* in culture. Can. J. Bot. 42: 1147-1149.

Pantidou, M.E., and Groves, J.W. 1966. Cultural studies of Boletaceae. Some species of *Suillus* and *Fuscoboletinus*. Can. J. Bot. 44: 1371-1392.

Pantidou, M.E., Watling, R., and Gonou, Z. 1983. Mycelial characters, anamorphs, and teleomorphs in genera and species of various families of Agaricales in culture. Mycotaxon 17: 409-432.

Park, J.Y. 1970. A change in color of aging mycorrhizal roots of *Tilia americana* formed by *Cenococcum graniforme*. Can. J. Bot. 48: 1339-1341.

Peña-Cabriales, J.J., and Valdés-Hgo, M. 1974. Rhizosphère du sapin. II. Mycorhizes: isolement et culture. Can. J. Microbiol. 20: 49-54.

Pomerleau, R. 1980. Flore des champignons au Québec et régions limitrophes. Les Editions la Presse, Ltée, Montréal.

Pomerleau, R., and Smith, A.H. 1962. *Fuscoboletinus*, a new genus of the Boletales. Brittonia 14: 156-172.

Randall, B.L., and Grand, L.F. 1986. Morphology and possible mycobiont (*Suillus pictus*) of a tuberculate ectomycorrhiza on *Pinus strobus*. Can. J. Bot. 64: 2182-2191.

Redhead, S.A. 1979. A study of the sphagnicolous fleshy Basidiomycetes in the eastern sections of the Canadian boreal forest. Ph.D. thesis, University of Toronto.

-------. 1989. A biogeographical overview of the Canadian mushroom flora. Can. J. Bot. 67: 3003-3062.

Redhead, S.A., and Watling, R. 1979. A new psammophilic *Leccinum*. Can. J. Bot. 57: 117-119.

Rendall, D.-L. 1980. The genus *Lactarius* occurring in the southern boreal forest region of Ontario and Quebec. M.Sc. thesis, University of Toronto.

Samson, J., and Fortin, J.A. 1988. Structural characterization of *Fuscoboletinus* and *Suillus* ectomycorrhizae synthesized on *Larix laricina*. Mycologia 80: 382-392.

Schild, D.E., Kennedy, A., and Stuart, M.R. 1988. Isolation of symbiont and associated fungi from ectomycorrhizas of Sitka spruce. Eur. J. For. Path. 18: 51-61.

Semerdzieva, M. 1965. Pestovåni a morfologickå pozorovåni nekterych hub celedi Agaricaceae *in vitro*. Ceska Mykologie 19: 230-239.

Siepmann, R. 1969. Artdiagnose einiger holzzerstörender Hymenomyceten an Hand von Reinkulturen II. Nova Hedwigia 18: 183-201.

Singer, R. 1986. The Agaricales in modern taxonomy. 4th ed. Koeltz Scientific Books, Koenigstein, Federal Republic of Germany.

Smith, A.H. 1951. Puffballs and their allies in Michigan. University of Michigan Press, Ann Arbor.

-------. 1966. New and noteworthy higher fungi from Michigan. Mich. Bot. 5: 18-25.

-------. 1973. Agaricales and related secotioid Gasteromycetes. In The Fungi: an advanced treatise. Edited by G.C.Ainsworth, F.K.Sparrow and A.S.Sussman. Academic Press, New York. pp. 421-450.

Smith, A.H., and Thiers, H.D. 1971. The boletes of Michigan. University of Michigan Press, Ann Arbor.

Smith, A.H., and Zeller, S.M. 1966. A preliminary account of the North American species of Rhizopogon. Mem. N.Y. Bot. Gard. 14(2): 1-178.

Smith, A.H., Smith, H.V., and Weber, N.S. 1981. How to know the non-gilled mushrooms. 2nd ed. Wm. C. Brown Co., Dubuque, Iowa.

Snell, W.H., and Dick, E.A. 1970. The boleti of northeastern North America. Verlag J. Cramer, Lehre, Federal Republic of Germany.

Sobotka, A. 1954. Cisté kultury z plodnic mykorrhitickych hub. Prace vyzkum Ust. lesn. CSR 6: 101-123.

Stalpers, J.A. 1978. Identification of wood-inhabiting Aphyllophorales in pure culture. Stud. Mycol. 16: 1-248.

Stanis, V.F. 1979. Russula species occurring in the boreal region of Ontario and Quebec, Canada. M.Sc. thesis, University of Toronto.

Sutara, J. 1987. The limit between the genera Boletinus and Suillus. Ceska Mykologie 41: 139-152.

Taylor, A.F.S., and Alexander, I.J. 1989. Ectomycorrhizal synthesis with an isolate of Russula aeruginea. Mycol. Res. 92: 103-107.

Thiers, H.D. 1975. The status of the genus Suillus in the United States. Beih. Nova Hedwigia 51: 247-278.

-------. 1984. The secotioid syndrome. Mycologia 76: 1-8.

Trappe, J.M. 1964. Mycorrhizal hosts and distribution of Cenococcum graniforme. Lloydia 27: 100-106.

-------. 1969. Studies on Cenococcum graniforme I. An efficient method for isolation from sclerotia. Can. J. Bot. 47: 1389-1390.

-------. 1971. Mycorrhiza-forming Ascomycetes. In Mycorrhizae: Proceedings of the first North American conference on mycorrhizae. Edited by E.Hacskaylo. USDA Forest Service misc. publ. No. 1189. pp. 19-37.

-------. 1975. A revision of the genus Alpova with notes on Rhizopogon and Melanogastraceae. Beih. Nova Hedwigia 51: 279-309.

Turner, N.J., Kuhnlein, H.V., and Egger, K.N. 1987. The cottonwood mushroom (Tricholoma populinum): a food resource of the Interior Salish Indian peoples of British Columbia. Can. J. Bot. 65: 921-927.

Westhuizen, G.C.A. van der. 1958. Studies of wood-rotting fungi: I. Cultural characteristics of some common species. Bothalia 7: 83-107.

Westhuizen, G.C.A. van der, and Eicker, A. 1989. The morphological and cultural characters of Pisolithus tinctorius (Gasteromycetes) in South Africa. S. Afr. J. Bot. 55: 17-21.

Wolfe, C.B. 1989. Studies in the genus Xanthoconium (Boletaceae). III. Cultural studies. Mycotaxon 35: 75-84.

Zak, B. 1971. Characterization and identification of Douglas-fir mycorrhizae. In Mycorrhizae: Proceedings of the first North American conference on mycorrhizae. Edited by E.Hacskaylo. USDA Forest Service Misc. Publ. 1189. pp. 38-52.

Zak, B., and Bryan, W.C. 1963. Isolation of fungal symbionts from pine mycorrhizae. Forest Sci. 9: 270-278.

Zak, B., and Marx, D.H. 1964. Isolation of mycorrhizal fungi from roots of individual slash pines. Forest Sci. 10: 214-222.

Zeller, S.M. 1947. More notes on Gasteromycetes. Mycologia 39: 282-312.

MYCOTAXON

Volume XLII, pp. 505-509 October-December 1991

BOOK REVIEWS

L. M. Kohn, Book Review Editor

Handbook of Protoctista, Edited by L. Margulis, J. O. Corliss, M. Melkonian, and D. J. Chapman. Cloth hardcover, 914 pp., 1990. Jones and Bartlett Publishers, Inc., 20 Park Plaza, Boston, MA 02116 U.S.A. ISBN 0-86720-052-9. US$195.--

Mycologists need a vision of the place of the fungi in the broad sweep of biosystematics. Here is a monumental book that initially claims our attention by including detailed treatments of three fungal and several pseudofungal groups, then, by placing them among other comparable evolutionary lines, invites us to re-think the nature and the relationships of those groups.

Of the five living Kingdoms now recognized by most biologists, Kingdom Protoctista (or Protista) arguably has the least satisfactory logical underpinning, simply because it encompasses such a dazzling display of diversity. All starting with roughly the same basic set of multiple-symbiosis, eukaryotic equipment, the protoctista have rearranged those organelles in myriad ways (at least 100,000 species). Many protoctistan phyla have been around for hundreds of millions of years, and anyone who might be tempted to feel superior to these unicells should remember that without this plethora of evolutionary experiments, the biosphere would never have been enriched by the super-genomes that gave rise to the animals, the plants - and the Eumycotan fungi.

Some of the phyla in this book are important to us because they cause disease. Others are wonderful teaching or research tools. But some biologists study them simply because they represent the best look we can get into the Pandora's box of eukaryotan evolution: ongoing experiments, still steeped in ancient biological traditions, but still perhaps inventing the future.

Now, as we study them with more and more sophisticated techniques, the protoctista are no longer just animated blobs. This book reveals their internal architecture: their organelles are named, characterized, and beautifully illustrated; in some cases even their ancestry is traced. The magnificent reconstructions of whole cells, and of kinetids (e.g., pp. 188, 213, 241, 248, 295, 476, 493, 505, 638, 682) are classics of electronmicrography, and in some cases of biological art, and they allow fascinating comparisons. Yet there is much more to learn. There are still organelles in protoctistan fungi called 'rumposomes' and 'striated discs' of whose function we are unaware. And some phyla are so removed from the others that their relationships are still unclear.

The four editors and 61 authors of this large, impressive and expensive book have provided a most welcome benchmark; a compilation which will, if we can digest its sheer size and complexity, be a useful guide to future studies of this fascinating Kingdom. Where so many authors are involved, it is perhaps to be expected that there would be some variety of approach, some lack of stylistic unity. Nevertheless, this provides insight, as we learn how certain features much studied in one group have not yet been fully explored in another.

Among the 61 contributors to this tome are such well-known mycologists as Don Barr (Chytridiomycota), Michael Dick (Oomycota), Lafayette Frederick (Myxomycota), Mel Fuller (Hyphochytriomycota), and David Porter (Labyrinthulomycota). Treatments of the groups vary considerably in length, to some extent reflecting what we know about them. But this book clearly reveals the protoctistan nature, both of three groups we claim as fungi, and of several others which are still dealt with in mycological journals, despite their entirely non-fungal way of life. Phyla such as Labyrinthulomycota, Plasmodiophoromycota, Acrasea, Dictyostelida, and Myxomycota are shown to be, not merely peripheral to mycology, but external to it. They should in some cases be renamed (the suffix -mycota is downright misleading), and should be dealt with in journals of Protoctistology. Lurking on the fringes of mycology, they merely muddy the waters, making it impossible to produce a rational definition of a fungus.

All mycologists should read the introduction to this book: it succinctly states what protoctista are, and which eukaryotic groups are excluded (animals, plants and [Eumycotan] fungi). It discusses the origin of the eukaryotic cell, and tabulates the 35 protoctistan phyla in four groups, according to whether they lack flagella (undulipodia) or have reversible formation of these organelles, and according to whether they have complex sexual cycles or not. Modes of nutrition are listed and compared. Mycologists should consider these criteria and make some decisions about historical inclusions within the body mycotan: it is high time for some mycological consensus and for some action by journal editiors.

The only unfortunate feature of the introduction is its insistence that the phyla dealt with in this book are non-fungal. Mycologists will not so easily give up the (Divisions) Oomycota and Chytridiomycota - and there is not good reason why they should. These organisms may not be closely related to the Eumycotan fungi (Ascomycetes, Basidiomycetes, Zygomycetes), but their life-form and ecology are essentially fungal. Just as algal ecology inevitably includes the prokaryotic Cyanobacteria, so must the practice of mycology embrace protoctistan groups which exhibit that quintessentially fungal trademark, the hypha.

Mycologists will find wonderfully concise yet wide-ranging treatments of the Oomycota and the Chytridiomycota, and a brief piece on the Hyphochytriomycota (reflecting the paucity of taxa, and of our knowledge). Students needing a crash course in these groups should be sent to this book. My only criticism is that some of the electronmicrographs are murkily reproduced, and therefore less informative than they should be. Most chapters have the following subheadings: Introduction, Habitats and ecology, Characterization and recognition, Maintenance and cultivation, Evolutionary history, and References. The last will allow the dedicated to dig further, and pages 727-807 are taken up with an amazingly extensive glossary. Readers should be warned that there are three indexes: organism, author and general (103 pages in all). I would have preferred a single, all-inclusive index.

The fate I fear may befall this book is that it will be used just as a kind of Dictionary or Encyclopaedia, simply to be referred to for information on specific groups, rather than read, or at least browsed, for the comparisons it encourages, and the overview it presents. One of the major problems with current science is that its bugeoning database and increasingly complex techniques force most people to concentrate fiercely on their specialty to the exclusion of almost everything else. And yet, if we are to achieve the overall synthesis of which we say we dream, more of us are going to have to sit down and read widely. Although most young scientists of today cannot afford to be generalists, I hope that at some point when their careers are secure they will take time to look at the big picture, a fair swath of which is limned in this book. Such omnispection is our only hope of perceiving the gossamer connections linking 30 million species.

I suspect that not too many individual myclogists will buy the **Handbook of Protoctista**, but surely all institutional libraries must own a copy. It is a book that repays browsing with fascinating insights, and the reader can even develop a personal position on the molecular biologists' plan to carve up the Protoctista into three Kingdoms: the ciliates, the flagellates and the microsporidia. This book is an elegant celebration of biodiversity which provides would-be protectors of the biosphere with fresh ammunition: for example, we need to preserve rhinos, not just for their delightfully crusty selves, but for their unique collection of intestinal symbionts, which live nowhere else. As a generalist, I will derive pleasure and instruction from the Handbook of Proctoctista for years to come. *Bryce Kendrick, Department of Biology, University of Waterloo, Canada.*

World Species of *Monilinia* (Fungi): Their Ecology, Biosystematics and Control, by L. R. Batra. Mycologia Memoir No. 16, published for The New York Botanical Garden in collaboration with The Mycological Society of America. Cloth hardcover, 246 pp., 1991. J. Cramer in der Gebrüder Borntraeger Verlagsbuchhandlung, Johanesstr. 3 A, D-7000 Stuttgart 1, Germany. (U. S. Agent: Lubrecht & Cramer, R.D. 1, Box 244, Forestburgh, NY 12777) ISBN 3-443-76006-6; USA ISBN 0-945345-34-8. DM 148.-- US$95.--

This book summarizes a lifetime of research on *Monilinia* , all species of which are parasites of woody perennials causing several economically important plant diseases. Chapters are arranged as follows: General

Introduction (including Materials and Methods); Morphology, Cytology and Reproduction; Bionomics, Host Relations and Control; Floral Mimicry and Insects as Vectors of Conidia; and Systematics Part. The book is well illustrated, with 14 tables and 22 plates, 4 of which are color. Those interested in ascomycete ontogeny, as well as systematics of the Sclerotiniaceae will wish to read chapter 1 on Morphology. The author's opinions, particularly on stromatal ontogeny and anatomy are deeply felt, and the system set forth will generate some discussion. I particularly enjoyed two chapters. Chapter 3 on distribution, host specificity and control of diseases offers a discussion of host phylogeny as well as the results of pathogenicity tests. Chapter 4, by S. W. T. Batra, describes the aggressive mimicry among certain species of the Disjunctoriae which facilitates insect dissemination of conidia and timely inoculation of the host. The author points out that this phenomenon is unique to *Monilinia* among the fungi, and is extremely refined as compared to similar examples in other organisms. Two dichotomous keys are provided in Chapter 5: a key to some genera of the Sclerotiniaceae forming apothecia on mummified fruits, and a key to the species of *Monilinia.* Species concepts continue to be based on host relations and relationship of the stroma to the host. The author recognizes 30 species of *Monilinia* (including two new species, a new subspecies, and one new combination); eight new form-species are described in *Monilia.* Among the 9 imperfectly known or excluded taxa, one new *Monilia* anamorph is described. Indices to species and form-species, and to hosts, are provided. Certainly all workers attempting to name specimens of *Monilinia* or *Monilia*, as well as those diagnosing diseases caused by this group of fungi will welcome this authoritative reference. Others will wish to peruse this work to learn about a well-kept secret, another elegant but little-investigated example of fungus-plant-insect coevolution. *L. M. K.*

An annotated list of the published names in *Mycosphaerella* and *Sphaerella*, by M. Corlett. Mycologia Memoir No. 18, published for The New York Botanical Garden in collaboration with The Mycological Society of America. Cloth hardcover, 328 pp., 1991. J. Cramer in der Gebrüder Borntraeger Verlagsbuchhandlung, Johannesstr. 3 A, D-7000 Stuttgart 1, Germany (U. S. Agent: Lubrecht & Cramer, R.D. 1, Box 244, Forestburgh, NY 12777). ISBN 3-443-76008-2; USA ISBN 0-945345-35-6. DM 128.-- US$85.--

This compilation provides an alphabetical listing of the published specific and infraspecific names in *Mycosphaerella* and *Sphaerella.* As the author points out, there are over 1800 published names in these genera and the literature is diffuse and in some cases inaccessible. Species occur on leaves and stems of as many as several hundred host plants and many are parasitic on economically important plants. Even though the taxonomic status of many names is uncertain, there is clearly a need for the comprehensive index of published names, with indices to hosts and anamorphs, provided in this volume. Original publications have been seen by the author for most citations and nomenclatural history, some descriptive data, country of origin or distribution, and host are indicated under each entry. Coding is fully accessible and explained in the Introduction. As with several other large genera of pathogenic fungi, such an index is the only point of entry to a morass of names. An important reference, and I hope a sign that compilations are in the offing for other difficult groups of fungi. *L. M. K.*

Molecular Systematics, Edited by D. M. Hillis and C. Moritz. 587 pp., 1990. Sinauer Associates Inc., Sunderland, MA 01375 U.S.A. Paperback, ISBN 0-87893-280-1, U.S.$33.-- Hardcover, ISBN 0-87893-279-8, U.S.$67.--

Mycologists may have missed this valuable book because it has been assembled mainly by animal and plant systematists and biometricians. The *raison d'être* of this volume is three-fold: to assist in selecting the most appropriate and economical technique for addressing a research problem, to offer a framework for developing characters in a systematics project, and to set rigorous standards for experimental design and analysis. Systematics is defined here in the broadest sense, stressing species delimitation, phylogenetic reconstruction, and population studies rather than classification (i.e., taxonomy). The book is arranged in three parts: Sampling, Molecular Techniques, and Analysis. There are individual chapters on Isozyme Electrophoresis, Immunological Techniques, Molecular Cytogenetics, DNA-DNA hybridization, Restriction Site Analysis, Sequencing, Intraspecific Differentiation, and Phylogeny Reconstruction. Protocols are provided, but more importantly, the fine points of character selection and data analysis are set forth with areas of controversy fully exposed. Of limited appeal may be the chapters on immunological techniques (too narrowly focussed on one approach), cytogenetics (no discussion of electrophoretic karyotyping), and intraspecific differentiation (too dependent on a genetic data that is often unattainable in some groups of fungi). On the other hand, anyone interested in systematics will be stimulated by the introductory chapter ("Context and Controversies": molecules vs. morphology, constancy of evolutionary rates, neutrality, homology and similarity) and the concluding chapter (budget projections for choosing a technique, predictions of time from molecular data). The treatment of phylogeny reconstruction by Swofford and Olsen provides an excellent overview and a list of available software packages. This is a current, savvy introduction to the field, one that sets a universal perspective (and standard) for studies in systematics that is much needed in mycology. Strongly suggested for researchers using molecular techniques in fungal systematics, must reading for those entering the field and their students! *L. M. K.*

MYCOTAXON

Volume XLII, pp.511 October-December 1991

Notice: The Second Regional Mycological Conference
(7-10 October 1992)
Organized by Al-Azhar University
Under the auspices of the
African Mycological Association (AMA) and
the International Mycological Association (IMA)

Sections:
- 1-Applied Mycology
- 2-Fungal Diseases and Antifungal Agents
- 3-Fungi and Toxicology
- 4-Fungi and Environmental Pollution
- 5-Metabolism in Fungi
- 6-Ecology and Taxonomy of Fungi
- 7-Mushroom Science

President:
Al-Azhar University President, Prof. A. H. El-Sheikh
Secretary-General:
Prof. A. A. Razak

The Second Regional Mycological Conference will be held at El-Sheikh Saleh Center for Conferences at the campus of Al-Azhar University, Madinet Nasr, Cairo, Egypt. The language of the conference will be English. No simultaneous translation of lectures will be available. All contributions must be submitted in English. The Conference fee is $100 US (One hundred U. S. dollars) to cover registration and the printing of materials.

For accomodations, several classes of hotels are located within walking distance of the conference center; various room rates will be offered. An excursion program of several trips before and after the conference is planned.

Deadline for submission of abstracts: November 30, 1991; manuscripts, March 31, 1992. Your abstract cannot be accepted until the registration fee has been received.

For details concerning submission of abstracts, registration and the excursion program, Address correspondence to the Secretary- General:

Prof. A. A. Razak
P. O. Box 8104
Massaken Madinet Nasr 11371
Madinet Nasr, Cairo, EGYPT

AL-AZHAR UNIV.
RMC 2

MYCOTAXON

Volume XLII, pp. 512-513 October-December 1991

INSTRUCTIONS TO AUTHORS

The fundamentals of preparing camera-ready copy for publication are summarized here, incorporating the changes that have occurred since the "Revised Instructions to Authors for Preparing Camera-Ready Manuscripts for MYCOTAXON" appeared in MYCOTAXON 26: 497-510. 1986. As that account goes into further detail than this summary, all authors are encouraged to look up volume 26, especially if they have questions unanswered in this summary.

What has changed since 1986:

★ Manuscripts are to be mailed to the *Editor-in-Chief*, Jean Boise Cargill, Harvard University Herbaria, 22 Divinity Ave., Cambridge, Massachusetts, 02138, U. S. A. (see MYCOTAXON 38: 500. 1990.)

★ Authors must send a copy of the reviewer's comments to the *Editor-in-Chief* (see MYCOTAXON 36: 496. 1990.) along with the manuscript.

★ Authors are requested to send a **photocopy** of the camera-ready manuscript. The photocopy will be used in preparing the index, thus it is not necessary to copy photographs. However, text planned to appear on the same page as photographs should be included in the photocopy.

The Fundamentals:

☞**The Format:** All manuscripts must correspond to one of the following formats: 100%, Elite (88%) or Pica (73%). To begin, draw a rectangle for the format you choose and for **every page** (with one exception) make sure that the text fills the rectangle, but does not extend beyond the rectangle. The first page of the article is the exception to the rule because it is shorter than the other pages. The author must **leave room at the top of the first manuscript page** for the MYCOTAXON heading that is added by the editor.

Format	**Dimensions**	**Point size**	**Leave blank p. 1**
100%	17.6 x 11 cm	**	2 cm
Elite	20 x 12.5 cm	10	2 cm
Pica	24 x 15 cm	12	2.4 cm

Make sure that extraneous printing on the page, e. g. headers, page numbers, are well outside of the rectangle, that is at least 2 cm. Preferably, authors are asked to not print a heading on the page, but add then after printing using a soft pencil. Also, keep in mind that **all articles begin on an odd-numbered page,** that is, right-hand page. Plan your text and illustrations accordingly so that the reader can view an illustration while reading the corresponding text.

☞**Illustrations:** Authors may use a larger format for illustrations, but the size should be proportional to the above formats. To calculate alternative formats for illustrations see MYCOTAXON 36: 103. Also, **mount photographs on a separate, heavier board**. When authors wish to provide a caption to a photograph it must be mailed on a separate sheet, leaving blank space where the photographic plate is planned to appear.

☞**Reviewers:** It is the responsibility of the authors of MYCOTAXON to solicit and respond to reviewer's comments before sending a camera-ready manuscript to the editor. Send a copy of the reviewer's comments to the editor along with the camera-ready manuscript. If the manuscript has been revised significantly, also include the earlier, reviewed draft.

☞**Avoiding page charges:** Under two circumstances the author will be charged a fee for publication. To avoid extra charges, use **only one photographic plate per 10 pages**. For example, a manuscript of nine pages with two photographic plates will incur the extra plate charge of $18.00; an eleven page manuscript with two photographic plates will not incur an extra plate charge. **Furthermore,** manuscripts that are **longer than 64 pages** will incur a page charge of $18.00 for each additional page. For example, the author of a manuscript that is 68 pages will be expected to pay page charges of 4 x $18 = $72.

Common errors:

✲ **Not allowing space at the top of the first page** of the article for the MYCOTAXON heading.

✲ **Printing a heading too close to manuscript text.** Keep any printing that is not meant for the journal printing well away from the rectangle containing the camera-ready copy.

✲ **Not checking the page length of manuscript** against the selected format dimensions. This problem is especially prevalent in manuscripts prepared on word processors. The result is excessive blank space on the final printed page.

✲ **Not planning illustrations** in a format that is **proportional** to the final format size. Consider the finished, reduced dimensions of an illustration during the initial layout. Failure to do so may result in an oddly shaped illustration in the final printing.

✲ **Photographic plates and text combined on a single sheet of paper**. The photo-offset process requires that text and photographic plates (half-tones) be prepared by separate processes that are combined in the final printing. Send text and photographs on separate pages. But on the text page, arrange the text exactly as it will appear within the final page format. For example if the text is a caption to the photograph, prepare the text at the bottom of the page just as if the photograph was present on the page.

✲ **Not sending the presubmission review to the Editor** along with the camera-ready copy and a photocopy for indexing.

Good Luck! The Editors look forward to receiving your manuscript.

Author Index to Volume Forty-two

Bagyanarayana, G., and P. Jagadeeswar. Miscellaneous notes on Indian Cercosporeae. 319-326

Bentivenga, Stephen P.and B. A. D. Hetrick. *Glomus mortonii* sp. nov., a previously undescribed species in the Glomaceae isolated from the Tallgrass Prairie in Kansas. 9-15

Blackwell, Will H.and Martha J. Powell. A nomenclatural synopsis of *Septosperma* (Chytridiomycetes) and emendation of *S. rhizophydii* . 43-52

Bougher, N. L. and H. D. Thiers. An indigenous species of *Leccinum* (Boletaceae) from Australia. 255-262

Brusse, Franklin A. A new species in the lichen genus *Parmelia* (Parmeliaceae, Ascomycotina),from the Blouberg, Northern Transvaal, South Africa, with further notes on southern Africa lichens. 163-169

_____. and Colin H. Dickinson. A new foliicolous species in the lichen genus *Porina* (Porinaceae, Pyrenulales) from southern Africa. 347-350

_____. and Ingvar Kärnefelt. The new southern hemisphere lichen genus *Coelopogon* (Lecanorales, Ascomycotina), with a new species from Southern Africa. 35-41

Büdel, Burkhard, José Maria Egea and H. Thorsten Lumbsch. Nomenclatural remarks on the lichens *Heppia solorinoides, Peltula obscurans* and *P. placodizans*. 245-248

Cano, J. see Guarro, Cano and de Vroey

Castañeda Ruiz, Rafael F. and W. Gams. A new species of *Phialomyces*. 239-243

Cazares, Efren and James M. Trappe. Alpine and subalpine fungi of the Cascade and Olympic Mountains. 2.*Macowanites lymanensis* sp. nov. 333-338

_____. and _____. Alpine and subalpine fungi of the Cascade and Olympic Mountains. 3.*Gastroboletus ruber* comb. nov. 339-345

De, A. B. A new species of *Phanerochaete* (Aphyllophorales, Corticiaceae) from India. 29-34

Deacon, J. W. ,S. A. K. Laing and L. A. Berry. *Pythium mycoparasiticum* sp.nov., an aggressive mycoparasite from British soils.1-8

Desjardin, Dennis E. A new species of *Hemimycena* (Agaricales, Tricholomataceae) from Anza Borrego Desert of Southern California. 187-192

Dickinson, Colin see Brusse and Dickinson

Egea, José Maria see Büdel, Egea and Lumbsch

Estrada-Torres, A. see Hernández-Cuevas, Rodríguez-Palma, Galindo-Flores and Estrada-Torres

Feige, G. Benno see Lumbsch, Schmitz and Feige

Galán, R. see Moreno, Galán and Montecchi

Galindo-Flores, G. see Hernández-Cuevas, Rodríguez-Palma, Galindo-Flores and Estrada-Torres

Gams, W. see Castañeda Ruiz and Gams

Goos, R. D. see Hosagoudar and Goos

Guarro, J., J. Cano, and Ch. de Vroey. *Nannizziopsis* (Ascomycotina) and related genera. 193-200

Hallenberg, Nils. Pairing tests with species of Aphyllophorales (Basidiomycetes) from two phytogeographically isloated areas. 355-386

Hernández-Cuevas, L., M. Rodríguez-Palma, G. Galindo-Flores and A. Estrada-Torres. New records of Myxomycetes from Mexico. 17-27

Hetrick, B. A. D. see Bentivenga and Hetrick

Hjortstam, Kurt. *Athelopsis* instead of *Pteridomycetes* (Corticiaceae, Basidiomycetes). 149-154

Hosagoudar, V. B. and R. D. Goos. Meliolaceae of South India - X. 125-147

Hutchison, Leonard J. Description and identification of cultures of ectomycorrhizal fungi found in North America. 387-504

Hyde, Kevin D. and Elijah Philemon. *Capitorostrum cocoes* sp. nov., causing leaf spot of *Cocos nucifera*. 95-97

Iturriaga, Teresita. New combinations and new synonyms in the genus *Claussenomyces*. 327-332

Jagadeeswar, P. see Bagyanarayana and Jagadeeswar

Kärnefelt, Ingvar see Brusse and Kärnefelt.

Kohn, L. M. Book Reviews. 505-509

Krupinsky, Joseph M. see Morgan-Jones, Owsley and Krupinsky

Laing, S. A. K. see Deacon, Laing and Berry

Lumbsch, H. Thorsten, Kerstin E. Schmitz and G. Benno Feige. *"Lecanora" opiniconensis* : a placodioid member of the Parmeliaceae (lichenized Ascomycotina). 77-87

_____. see Büdel, Egea and Lumbsch

McKemy, John M. and Gareth Morgan-Jones. Studies in the genus *Cladosporium* sensu lato. V. Concerning the type species*Cladosporium herbarum*. 307-317

McKenzie, E. H. C. Dematiaceous hyphomycetes on *Freycinetia* (Pandanaceae). 3. *Chalarodes* gen. nov. 89-93

_____. *Buergenerula zelandica* sp. nov. on *Carex spp*. in New Zealand. 351-353

Montecchi, A. see Moreno, Galán and Montecchi

Moreno, G., R. Galán and A. Montecchi. Hypogeous fungi from peninsular Spain. II. 201-238

_____ . see Robich, Moreno and Pöder

Morgan-Jones,Gareth , Michele R. Owsley and Joseph M. Krupinsky. Notes on Coelomycetes. IV. *Phyllosticta andropogonivora*, causal organism of leafspot disease of *Schizachyrium scoparium* (Little Bluestem) and *Andropogon gerardii* (Big and Sand Bluestem), reclassified in *Ascochyta*. 53-61

_____ . see McKemy and Morgan-Jones

Nash III, T. H. see Triebel, Rambold and Nash

Owsley, Michele R. see Morgan-Jones, Owsley and Krupinsky

Pacioni, Giovanni and Giancarla Pomponi. Genotypic patterns of some Italian populations of the *Tuber aestivum-T. mesentericum* complex. 171-179

Philemon, Elikah see Hyde and Philemon

Pöder, R. see Robich, Moreno and Pöder

Pomponi, Giancarla see Pacioni and Pomponi

Powell, Martha J. see Blackwell and Powell

Ramaley, Annette. Fungi of *Yucca baccata* . 1. *Piptarthron pluriloculare* and its teleomorph, *Planistroma yuccigena*.. 63-75

Rambold, G. see Triebel, Rambold and Nash

Reynolds, Don R. A phylogeny of fissitunicate ascostromatic fungi. 99-124

Robich, G., G. Moreno and R. Pöder. *Marasmiellus dunensis* (Marasmiaceae, Agaricales), a new species from the European Mediterranean.181-186

Rodríguez-Palma, M. see Hernández-Cuevas, Rodríguez-Palma, Galindo-Flores and Estrada-Torres

Roldan, A. Pure culture studies on *Volucrispora graminea* and *Isthmotricladia britannica* (Hyphomycetes). 297-306

Schmitz, Kerstin E. see Lumbsch, Schmitz and Feige

Thiers, H. see Bougher and Thiers

Timdal, Einar. *Anamylopsora*, a new genus in the Lecideaceae. 249-254

Trappe, James M. see Cazares and Trappe

Triebel, D.,G. Rambold and T. H. Nash III. On lichenicolous fungi from continental North America. 263-296

Vroey, Ch. de see Guarro, Cano and de Vroey

Zhang, Bin-Cheng. Morphology, cytology and taxonomy of *Hydnotrya cerebriformis* (Pezizales). 155-162

INDEX TO FUNGOUS AND LICHEN TAXA, VOLUME FORTY-TWO

This index includes the names of genera, infrageneric taxa, species, and infraspecific taxa. New names are in **boldface**, as are the page numbers on which new taxa are proposed.

Abortiporus 385
Abrothallus
  bertianus 264-265
  microspermus 292
  parmeliarum 265
  peyritschii 265
  prodiens 265
Acarospora 269, 275, 284, 290
  collemacea 246
  fuscata 266, 280, 290
  glaucocarpa 265, 280
  macrospora 265
  nitida 275
  schleicheri 280-281, 285, 290
Acladium
  herbarum 308
Acremonium 243
Actinoplaca
  strigulacea 165
Adelococcus
  alpestris 265
Agaricus
  bisporus 173, 175
  brunnescens 175
Ajellomyces 197, 199
Aleurodiscus 154
Alpova 503
  diplophloeus 392, 394, 397, 399, 488-489
Amanita 389-391, 431, 450, 453, 494, 497
  brunnescens 401, 450
  citrina 401, 451
  flavoconia 401, 403, 451
  muscaria 392, 394, 399-402, 404, 450, 452-453, 499
  rubescens 403, 450, 453-454
Amauroascus 193, 195, 197
  albicans 195
  candidus 196
Amazonia
  peregrina 126
  syzygii 126
Amygdalaria 271-272
  elegantior 271-272
  panaeola 271-272
Anamylopsora 249-**250**, 251-252
  pulcherrima 249-**250**, 252-253
Anzina 252
  carneonivea 254
Apinisia 196-197, 199
  graminicola 197, 199-200
  queenslandica 197
  racovitzae 193, **199**
Apiocrea
  chrysosperma 495
Arachniotus 193, 199
  albicans 195
Arachnotheca 193, 195, 197
  albicans 193, 195-196
  glomerata 193, 199
  vriesii 193, 196
Arctopeltis 86
Arthonia 267
  clemens 266
  epiphyscia 266
  glaucomaria 267-268
    var. pallidae 268
  intexta 267, 294
  subfuscicola 263, **268**
Arthopyrenia
  glebarum 291
Ascochyta 53-54, 56, 58-61
  andropogonivora 55-**56**, 58-60
  brachypodii 59
  elymi 59
  graminicola 59
  leptospora 59
  lycopersici 60
  phyllachorides
    f. melicae 60
  pisi 56
  poagena 59
  sorghi 59
Aspicilia 269
Asteridiella 95, 125
  acronychiae 127
  acronychiae-pedunculatae 125, **126**, 141
  anamalaiana 125, **127**, 141
  buettneriae 127
  cyclopoda 127
  formosensis 128
  fraseniana 97

[Asteridiella] malloticola 125, 128
  viveknanthanii 128
Asterina 119
Asteromella 54
Asteromellopsis 68
Asterophlyctis 51
  irregularis 44, 47
  sacroptoides 51
Astraeus 188
Athelia
  decipiens 357
Athelopsis 149-153
  baculifera 153-154
  bananispora 149, **151**, 153-154
  crystallifera 153
  galzinii 149-151, 153-154
  glaucina 150, 153-154
  lacerata 149-150, 153
  lembospora 149, 153-154
  subinconspicua 153-154
Aureobasidium 74-75
  pullulans 308
Auxarthron 197
Averswaldiella 72-73

Bacidina
  pallidocarnea 165
Baeomyces
  rufus 284
Bagnisiella 72-74
  australis 75
Balsamia 202, 236
  fragiformis 202
  vulgaris 202-203
Bankera 498
  fuligineo-alba 396, 404, 479
Bellemerea
  alpina 280-281
Belonidium
  clarkei 328, 331
  imperspicuum 328
  tympanoides 330
  viridi-atrum 327, 331
Belonium
  tympanoides 330-331
Biatora 272
  vernalis 272
Boletellus
  russellii 397, 411
Boletinus 390-391, 412, 482, 490, 494-495, 500, 502-503
  cavipes 397, 412
  paluster 397, 413
Boletus 262, 339, 343
  sect. Subtomentosi 345
  edulis 394, 402, 430-431
  elegans 418, 499
  luteus 501
  ornatipes 394, 398, 401, 431
  rufus 434
  versipelis
    var. aurantiacus 434
Botryosphaeria 63
Brevicellicium
  olivascens 358
Briganteiaea 293
Bryocaulon 40
Bryoria 36
Buellia 269, 284
  badia 268-269, 285
  spuria 269
Buelliella 276
Buergenerula 351, 353
  biseptata 353
  caricis 353
  zelandica 351-353
Bulbothrix 168

Caloplaca 269-270, 278
  arenaria 280
  cerina 279
  cinnabarina 276
  modesta 270, 276-277
Candelariella 269, 284
  rosulans 269, 284
  terrigena 269
  vitellina 269
  xanthostigma 269
Canomaculina 168
Capitorostrum 97
  asteridiellae 95, 97
  cocoes 95-97
Capnodium 114
  salicinum 114, 119
Carbonea 274
  vitellinaria 269, 284
Caudophoma 54
Cavernularia 265, 282
  hultenii 282
  lophyrea 265
Cecidonia 296
Celidium
  varians
    f. pallidae 268
    var. pallidae 268
Cenococcum 493
  geophilum 388, 391-392, 394, 396,

[Cenococcum geophilum] 492-493, 500
  graniforme 492, 500-503
  granuliforme 492
Ceratocystis 93
Cercidospora 293
  caudata 270
  epicarphinea 270
  epipolytropa 270
  ulothii 270
Cercoseptoria 326
Cercospora 322, 326
  aciculina 320
  agerati-conyzoidis 319, 321
  asplenifoliae 321, 323
  atylosiae 320
  atylosiicola 320-321
  bombacis 321, 323
  borreriae 322
  borreriae-strictae 320-321
  canescens 324
  celosiae 321, 324
  citrullina 324
  conyzoides 320
  eupatorii 326
  gaillardiae 324
  guatemalensis 321, 324
  instabilis 326
  ipomoeae 324
  malvacearum 321, 324
  rhynchosiae 323
  rhynchosiae-minimae 323
  spermococes 324
  "trichodesmae" 322
  trichodesmatis 322
  ubatubensis 322
Ceriporiopsis
  pannocincta 358
Cetraria 36
  epiphorella 39
Chaetochalara 93
Chaetosphaeria
  vermicularioides 316
Chalara 89, 93
Chalarodes 89
  bisetis 89-90, **91**
  obconica 89, **91**-92
Chalciporus
  piperatus 398, 430
Chamonixia 345
Chlamydopus
  meyenianus 188
Chloridium 317
  phaeosporum 317
  virescens 316
    var. allantosporum 317
    var. caudigerum 317
Chlorociboria
  salviicolor 327
Chlorosplenium 332
Choiromyces
  gangliformis 162, 202
  magnusii 202-203, 206, 211
Chondrostereum
  purpureum 358
Chrysosporium 193, 195, 197, 199
Cladina 278
Cladonia 278
  pyxidata 278
Cladosporium 74, 307-310, 314-317
  abietinum 307
  asterinae 315
  atrum 307-308
  aureum 307-308
  breviramosum 315
  chlorocephalum 315, 317
  cladosporioides 309, 315
  colocasiae 314, 316
  epiphyllum 308
  fascatum 308
  fasciculare 308
  fumago 308
  fuscum 308
  geniculatum 315
  graminum 308
  herbarum 307-310, 312-317
  macrocarpum 310, 315-316
  musae 315
  oxysporum 314-315
  paeoniae 317
  smilacis 308
  sphaerospermum 315
  tenuissimum 315
  umbrinum 308
  uredinicola 317
Claussenomyces 327-328, 332
  atrovirens 327
  canariensis 327
  clavatus 327
  dacrymycetoideus 327
  imperspicuus 327-328
  hydnicola 327
  jahnianus 327
  luteoviridis 327-328
  olivaceus 327
  pini 327
  prasinulus 327, 331
  pseudotsugae 327
  pusillus 327, 330

[Claussenomyces] salviicolor 327
  tympanoides 328, 330
Clauzadeana
  macula 280-281
Clypeococcum
  hypocenomyceae 271
Coccodiella 72-73
Coelocaulon 35-36, 40
  aculeatum 37-38
  crespoae 37-38
  muricatum 37-38
  steppae 37-38
Coelopogon 35-36
  abraxas 35, 37-39, 40
  epiphorellus 35, 37-39
Coelosporium 308
  fruticulosum 308
Coltricia
  perennis 398, 401, 479-480
Confertobasidium 154
Coniothyrium
  bartholomaei 63
Cornicularia 36-38, 40
  epiphorella 40
Corticium 384
  baculiferum 153
  crystalliferum 153
  glaucinum 150, 153
  laceratum 153
  lembosporum 153
  subinconspicuum 153
Cortinarius 389-391, 458, 461, 494
  allutus 391, 399, 458-459
  amoenolens 391, 399, 459
  anomalus 391, 394, 402, 459-460
  brunneus 391-392, 400, 403, 458, 460-461
  glaucopus 391, 399, 459-461
  hercynicus 496
  mucidus 392
  mucosus 399-400, 458, 462, 479
  subpurpurascens 399, 462
  variecolor 496
Coryne
  prasinula 331
Corynella 327, 332
  glabrovirens 331
  prasinula 331
Craterium
  paraguayense 17, 22-23
Cribraria
  mirabilis 19
Crinula 332
Cronartium
  quercuum 317
Cryptendoxyla 93
Cylindrobasidium
  evolvens 359

Dacampia
  hookeri 289
Dacryobolus
  sudans 359-360
Dactylospora
  amygdalariae 271, 273
  deminuta 272
  glaucomarioides 272
  purpurascens 271-272
  saxatilis 273
    var. saxatilis 273
  urceolata 272
Darluca
  filum 59
Delastria 236
Delicatula
  crispula 191
Dematium 307-308
  abietinum 307
  articulatum 308
  epiphyllum 307-308
  fuscum 307-308
  graminum 307-308
  herbarum 307-309, 312
  smilacis 308
  vulgare
    δ typharum 307
Dendrothele 151
Dichostereum
  durum 373-384
  sordulentum 373-384
Dictydium
  cancellatum 19
  mirabile 17-19
Dictyotrichiella
  semiimmersa 119
Diderma
  radiatum 17, 25
Didymella 53, 60, 293
  autumnalis 60
  exitialis 59-60
  graminicola 60
  lycopersici 60-61
  phleina 60
Didymellina 60
Didymosphaeria
  loliina 60
Dimelaena 274, 295
  oreina 273-274

Dimerella
  lutea 166
  zonata 166
Diplophlyctis 51
Diploschistes 279, 294-295
  scruposus 279
Dolichocarpus 295
Dothidea 68, 72-74, 104
  conspicua 68, 74

Echinothecium 286
  reticulatum 273
Elaphomyces 206, 396, 493, 500
  anthracinus 201, 204-206, 235
  granulatus 206
  persoonii 206
  trappei 201, **206**-207
Elasmomyces 337
Endocarpiscum
  aterrimum 246
  obscurans 246
Endocarpon
  reticulatum 245-246
Endococcus
  perpusillus 273
  propinquus 273-275
  rugulosus 273, 275
Enteridium
  olivaceum 17-18
Epilichen
  stellatus 275
Epithele 149, 151-152
  galzinii 149-152
Eudarluca
  caricis 59
Evernia 278

Flavoparmelia
  caperata 273, 292
Fomes
  pinicola 385
Fomitopsis
  rosea 360
Fumago 308
  vagans 308, 316
Fuscoboletinus 494, 502

Gastroboletus 339, 343, 345
  ruber 339-340, **341**-345
  turbinatus 343
Gastrosporium
  simplex 220
Gastrosuillus 339
Gautieria
  morchellaeformis 221-222, 235
Gelatinopsis 295
Geltingia 295
Genea 236
  klotzchii 208-209
  sphaerica 209
  verrucosa 209-210, 235
Geopora
  arenicola 209
  arenosa 209
  cooperi 211, 218
  nicaensis 211
Geoporella
  michaelis 162
Gloeocystidiellum
  clavuligerum 361-362, 385
  porosum 361-362, 385
Gloeodontia 384
  columbiensis 362-363
Gloeoporus 384
  conchoides 384
  dichrous 384
  pannocinctus 358, 384
Glomerella 72-73
Glomus 9
  clarum 11
  globiferum 14-15
  mortonii 9, **10**-14
  mosseae 14
  sinuosa 11
  tortuosum 14
Guignardia 54
Gymnoascus
  racovitzae 199
Gymnohydnotrya 162
Gymnomyces 238, 337
Gyrodon
  merulioides 502

Hebeloma 389-391, 396, 454-455, 457, 478, 494, 496-497
  crustuliniforme 400, 454-455
  cylindrosporum 400, 455
  longicaudum 400, 456
  mesophaeum 400, 456-457
  velutipes 400, 457
Helminthosporium 307
Helotiopsis 332
Helotium 190, 192
  californiense 188
  glabrovirens 331
  subimmaculatum 188
Hemimycena 187-188, 190-192
  crispula 191

[Hemimycena] cyphelloides 191
  delectabilis 188
  delicatella 188
  hirsuta 187, 191-192
  lactea 188
  minutissima 187, **188**-191
  pseudocrispula 191
Heppia 245-248
  acarosporoides 246
  deserticola 246
    f. minor 246
  hassei 246
  microacanensis
    var. adnata 246
  murorum 246
  obscurans 246
  placodizans 247
  reticulata 245-246
  solorinoides 245-246
Heterobasidion
  annosum 384
Heterodermia 283
  erinacea 166, 283
Heterosporium 315
  gracile 317
Hirschioporus
  sect. Polyporus 385
  abietinus 385
  fusco-violaceus 385
  laricinus 385
Histoplasma 197, 199
'Holmaya' 327
Holwaya 327, 332
  jahniana 327
  pusilla 330
Hydnangium 223, 392, 495
  carneum 223, 399, 491-492, 497, 501
Hydnellum 498
Hydnocystis
  clausa 235
Hydnotrya 155, 161
  cerebriformis 155-158, 160-161
  michaelis 161-162
  soehneri 158
  tulasnei 161-162, 209
Hygrophorus 390-391, 436, 496, 499
  eburneus 400, 436
  russula 400, 437
Hymenogaster 225, 238
  cerebellum 201, 224-225
  citrinum 201, 225
Hyphoderma
  cremeoalbum 363
  medioburiense 363
  praetermissum 363
  puberum 364
  roseocremeum 364
  transiens 364
Hyphodermella 154
Hyphodontia 151
  bugellensis 149, 151-153
  capitata 149, **151**-152
  capitulata 149
  nespori 365
  pruni 149, 151-152
  quercina 365
  subalutacea 366, 383
Hypocenomyce
  scalaris 271
Hypochnicium
  albostramineum 367
  eichleri 367, 385
  erikssonii 385
  polonense 368
  punctulatum 367
  sphaerosporum 385
Hypotrachyna 168
Hysterangium
  stoloniferum
    var. rubescens 201, 225-226

Immersaria 286
Irenopsis 125
  benguetensis 128
  thespesiae 125, 128
  triumfettae 128
  xanthophylli 125, **128**, 142
Isthmotricladia
  britannica 297, 303-305
  laeensis 303

Junghuhnia
  nitida 368

Karoowia 86-87
Karschia 276, 293
  inops 276
Kellermania 63, 75
  anomala 63
  attenuata 63
  multiseptata 63
  yuccaegena 63, 65
Kuehniella
  racovitzae 195-196, 199

Laccaria 223, 389-392, 396, 437, 478, 492, 494-496, 498, 501
  bicolor 391, 394, 399, 437-439, 494,

[Laccaria bicolor] 500-501
  laccata 392, 394, 399, 438-439, 441
   type I 439
   type II 439
  ochropurpurea 392, 394, 399, 440
  proxima 392, 394, 399, 440-441
Lactarius 337, 389-392, 396, 465, 472, 474, 477, 491, 494-495, 499, 501-502
  sect. Dapetes 391, 465-466, 469, 493
  affinis 405, 466, 471, 474
  chelidonius 401, 405, 466-467
  deliciosus 402-405, 467-469, 475, 494
  hibbardae 391, 405, 469
  indigo 401, 405, 467, 470
  mucidus 392, 405, 466, 470-471, 474
  pubescens 405, 471-472, 476
  rufus 405, 466, 471-472, 474
  subpurpureus 394, 402, 405, 469, 473-475, 494
  thejogalus 405, 466, 471, 474
  thyinos 402, 405, 469, 474-475, 494
  torminosus 394, 404, 472, 476
  vinaceorufescens 391, 404-405, 477
Lambdasporium 299
  viridense 299
Lecanora 83, 86, 254, 278, 284, 288-290
  subg. Placodium 85, 271
  albella 268
  argentata 84
  bipruinosa 289
  carpinea 268, 290
  cenisia 289
  chlarotera 278
  christoi 271
  contractula 87
  dispersa 266
  garovaglii 271
  impudens 282
  intumescens 290
  marginata 281
  muralis 271, 289
  novomexicana 271, 280-281, 289
  opiniconensis 77-78, 83-86
  pallida 268
  phaedrophthalma 289
  polytropa 77, 83-84, 270
  pulicaris 290
  reticulata 246
  rupicola 267-268, 285
  solorinoides 245-246
  subfusca 289
  subfuscata 84
  subradiosa 289
  swartzii 289
Leccinum 255-256, 389-390, 431-432, 434, 502
  sect. Leccinum 255, 261
  subsect. Obscura 261
  arenicola 401, 432
  aurantiacum 401-402, 433
  australiense 255-**256**, 258, 261
  extremiorientale 256
  griseum 261
  holopus 394, 397, 401, 434
  intusrubens 255-256, 261
  nigrescens 256
  oxydabile 434
  rotundifolia 434
  scabrum 434
  subglabripes 256
Lecidea 249, 252, 254, 275, 280, 286
  atrobrunnea 280, 286
  hedinii 250, 252
  lapicida 280
  lurida 252
  pulcherrima 249-250
  tessellata 275-276, 281
   var. athallina 281
  undulata 249-250, 252
  whakatipae 295
Lecidella 267-268, 281
  stigmatea 267
Lemonniera 306
Leptodothiorella 54
Lichenochora 277, 293
  thallina 277
  xanthoriae 263, **277**
Lichenoconium 293
  lecanorae 277
  pyxidatae 278
  xanthoriae 278
Lichenodiplis 279, 294
  lecanorae 278
Lichenostigma 295
  rugosa 279
Limacinia 104
Limacium
  eburneum 436
Lindtneria 385
Longula
  texensis 188

Macowanites 333, 337-338
  citrinus 337
  duranguensis 337
  lymanensis 333-334, **335**-337, 339

[Macowanites] mexicanus 337
Marasmiellus 183
  carneopallidum 182
  dunensis 181-182, 184-186
Marasmius 192
  oreades 183
  perreductus 191
  pusillissimus 191
  rosulatus 191
Martellia 238, 337
  mediterranea 201, **227**-230
  mistiformis 230
Mazosia
  melanophthalma 166
Melanelia 85, 264, 269, 278
Melanogaster
  ambiguus 233
  broomeianus 232-233
  variegatus 232-233
Melanomma 118
  fuscidulum 118
  pulvis-pyrius 118
Meliola 99, 102-103, 112, 125, 135, 140
  alstoniae 129
  altissimae 125, **129**, 142
  anamalaiana 127
  artocarpi 125, 130
  banosensis 131
    var. banosensis 130-131
    var. puereriae 125, **130**, 143
  bhesae 125, **131**, 143
  bicornis 132
  cantareirensis 130
  capensis
    var. malayensis 132
  ceropegiae 125, **132**-133, 144
  chandrasekharanii 133
  citricola 133
  clausenae 133
  connari
    var. connari 133-134
    var. indica 125, **133**-134, 144
  cookeana 130
  erythrinae 134
  floridensis 119
  gamblei 125, **134**-135, 145
  glycosmidis 135
  gneti 135
  groteana 135
  holigarnae 135
  hoyae 133
  linocierae-malabaricae 135
  lophopetali 131
  malabarensis 135
  malacotricha
    var. major 136
  memecylicola
    var. indica 125, **136**, 145
    var. memecylicola 136
  panici 136
  parvula 136
  parvuta 125
  pulchella 137
    var. pulcella 136-137
    var. syzygii 125, **136**, 146
  salleana 135
    var. smilacis 135
  semecarpicola 138
  teramni
    var. millettiae 125, **137**, 146
    var. teramni 137
  travancoricae 125, **138**, 147
  trewiae 125, **138**, 147
  tylophorae 133
  viticicola 130
  zanthoxyli 139
Meliolina 101, 120
Memnoniella 239, 243
Merismatium
  decolorans 279
  peregrinum 279
Micromphale 183
  carneopallidum 182-183
  carneo-pallidum 183
Microthelia 294
  subfuscicola 263, 268
Montagnea
  arenarius 188
Muellerella
  lichenicola 278, 280
  pygmaea 280
    var. athallina 280
    var. pygmaea 280
    var. ventosicola 281
Mycelium
  radicis-nigrostrigosum 493
Mycena 190, 192
  sect. Adonideae 188
  sect. Deminutivae 188
  albidula 188
  albissima 188
  crispula 191
  delectabilis 188
    var. bispora 191
  delicatella 188
  gypsella 191
  mauretanica
    var. apogama 191

[Mycena] mcmurphyi 188
  pseudocrispata 191
  pseudogibba 191
Mycoacia 154
  uda 368
Mycobilimbia
  berengeriana 279
Mycosphaerella 316-317
  tassiana 309-310, 315-316
  tulasnei 309-310
  typhae 316
Mycovellosiella
  cajani
    var. indica 326
Myelochroa 165, 168
Myxotrichum
  racovitzae 199

Nannizziopsis 193, 195-197
  albicans 193, **195**, 197, 199
  hispanica 193, 195-**196**, 197
  vriesii 195-197, 199
Neofuscelia 269
Nephroma 264

Obelidium 51
Ochrolechia
  tartarea 272
  upsaliensis 272
  yasudae 272
Octavianina 233
  asterosperma 201, 233-234
Odontia
  bugellensis 152
  pruni 152
  subalbicans 364
Odontiopsis 153
  ambigua 152
  hyphodontia 152
Ombrophila
  atrovirens
    var. prasinula 331
  prasinula 331
Omphalodium 78, 85
  pisacomense 77, 83, 85
Omphalora 78, 85, 87
  arizonica 77, 83, 85
Opegrapha
  rinodinae 296
Ophioparma
  ventosa 281

Pantospora 326
Paraparmelia 269
Parmelia 85, 163-165, 168, 265, 282
  subg. Bulbothrix 164-165
  subg. Flavoparmelia 163, 167
  subg. Hypotrachyna 163
  subg. Paraparmelia 163
  subg. Parmelinella 167
  subg. Parmelinopsis 164-165
  subg. Xanthoparmelia 164
    bahiana 163
    commensurata 166
    conspersa 87
    damaziana 165, 168
    decurata 163-165
    ectypa 163, **165**-166, 168
    erythrodes 163
    horrescens 165
    hypoprotocetrarica 164
    malabogoi 163, **165**-166, 168
    minarum 164-165
    mongaensis 163
    pachydactyla 163, 166
    rodriguesiana 163
    scytophylla 163
    sulcata 265, 278, 282
    tabacina 165
    usambarensis 166
    wallichiana 166
Parmelina 165, 168
Parmelinella 168
Parmelinopsis 168
  neodamaziana 165, 168
Parmotremopsis 168
Paxillus 390-391, 482, 489, 495
  involutus 392, 397, 434-435, 480, 484-485, 489, 497-498, 500
Peltula 245, 247-248
  decorticans 245, 247
  euploca 246-247
  obscurans 245-247
  placodizans 245, 247
  subglebosa 245, 247
Penicillium 239, 243
  subg. Furcatum 243
  cladosporioides 309
Peniophora
  sect. Coloratae 384
  cinerea 369, 383, 385
  incarnata 369
  limitata 371
  lycii 369
  meridionalis 370
  nuda 370
  pseudonuda 370
  rufomarginata 370-371, 382

[Peniophora] versicolor 371
  violaceolivida 370
Periconia 307
Peridiothelia
  grandiuscula 282
Pertusaria 273, 278, 288-289
  arizonica 273
  flavicans 273
Peziza 161
  prasinula 331
Phacopsis 282, 296
  oxyspora 282
Phaeophyscia
  hirsuta 267
Phaeopyxis 295
Phaeoramularia
  ajrekari 324-325
Phanerochaete 29, 33-34
  subg. Phanericium 33
  citri 29, 31, 33
  tuberculata 33
  xerophila 33
Pharcidia
  congesta 263, 290
  squamariae 289
Phellodon 498
Phialomyces 239, 243
  cubensis 239
  macrosporus 243
  striatus 239, 241-243
Phialophora 6
Phlebia 152
  lilascens 383
  livida 371
  radiata 372, 384
  rufa 372, 384
  segregata 372
  verruculosa 152
Phlebiella
  ardosiaca 373
  tulasnelloidea 373
Phlegmacium 501
Phlyctidium 51
  anomalum 43-45, 47
Phlyctochytrium 51
Phyllachora 72-75
  yuccae 74
Phyllosticta 53-54, 56, 59, 61
  andropogonivora 53-54, 56, 58, 60
  cruenta 54, 56
  healdii 54
Phyllostictina 54
Phoma 54, 58, 60-61
  americana 58
  eupyrena 58, 61
  exigua 58
    var. exigua 61
  herbarum 58, 60
  lycopersici 60-61
  medicaginis 58
    var. medicaginis 61
    var. pinodella 61
  multirostrata 58, 61
  pinodella 58
Phomopsis 54
Physarum
  rubiginosum 17, 23
  tropicale 17-18, 24
Physcia 274, 283, 285
  caesia 283
  dubia 283
  phaea 274
  wainioi 283
Piloderma
  bicolor 391, 400-401, 480
Pilophorus 272
Piptarthron 63, 65
  limbatum 63
  macrosporum 63, 65, 68
  pluriloculare 63, 65, 67-68, 74
  yuccae 63, 65, 68, 74-75
Pisolithus 390, 482, 489, 495, 497-498
  arhizus 394, 397, 480, 484-485, 500
  tinctorius 498-500, 503
Pithyella 332
Placodium 78
  subglebosum 246
Placopsis 254
Planistroma 69, 72-75
  yuccigena 63, **69**, 71, 74
Pleospora 104
Pleuroascus 197
Pleurosticta 83, 87
  acetabulum 77, 83, 85
Pleurotus 439
Podaxis
  pistillaris 188
Polycoccum 283, 294
  galligenum 283, 296
  sporastatiae 283
Polyporus
  abietinus 385
  dichrous 384
  pannocinctus 358, 384
Polysporina
  dubia 284
  lapponica 284
  simplex 284

Porina 347-349
  dwesica 347-349
  epiphylla 348
  phyllogena 167
  sphaerocephala 348-349
  virescens 348
Porpidia 274
  macrocarpa 274
  speirea 274
Protoblastenia
  rupestris 281
Protoparmelia
  badia 266, 286-287
Protothelenella
  sphinctrinoides 272
Prototrichia 20
  metallica 17, 19-20
Pseudephebe 264
Pseudocercospora 322, 326
  cajanicola 326
  eupatorii 325-326
  jasminicola 326
  pseudotrichodesmatis 322, 325
  rhynchosiicola 323, 325
  riachuelii 325-326
  subsessilis 326
  waltheriae 325-326
Pseudosphaeria 104
Psora 249, 251-252, 254
  concava 252
  crenata 252, 291
  decipiens 291
  pulcherrima 249-250
    var. elegantula 250
  tabacina 291
Psoroma
  hypnorum 266
Psorula
  rufonigra 252
Pteridomyces 149-151
  bananisporus 149-151
  bisporus 151
  capitatus 149, 151
  lacteus 152
  roseolus 152
  sphaericosporus 152
  subsphaericosporus 153
Punctelia 282
Pyrenidium
  actinellum 284, 294
Pyrenopsidium
  decorticans 247
Pyrenopsis 247
Pyrenula 104
Pyrrhospora sanguinolenta 166
Pythium 1, 4, 7-8
  acanthicum 1, 6-7
  mycoparasiticum 1, 3-7
  oligandrum 1, 6-8
  nunn 1, 4, 8
  periilum 4
  periplocum 1
  scleroteichum 1, 4, 6-8
  SWO 1, 4
  ultimum 8
  vexans 6-7

Radulomyces
  confluens 373, 382
Repetobasidium
  mirificum 374
Resinicium
  bicolor 374
Rhizocarpon 275, 281
  geographicum 274, 282
Rhizoclosmatium 51
Rhizophidium 51
Rhizophlyctis 51
Rhizophydium 46-47
  macrosporum 45
Rhizoplaca 78, 83, 85-86, 278
  chrysoleuca 77, 83, 85-86, 266
  melanophthalma 77, 83, 85, 287
  peltata 266
Rhizopogon 339, 343, 390, 485-486, 488, 490-491, 495, 497, 503
  rubescens 398, 485-488
  superiorensis 398, 486-488
  vinicolor 394, 398, 486-488
  vulgaris 398, 486-488
Rhymbocarpus 285
Rimularia
  badioatra 279
  gibbosa 279
Rinodina 269, 281, 295
  insularis 285
Rinodinella 295
Rollandina 199
  vriesii 193, 196
Rosellinia 295
Rozites
  caperata 391-392, 399, 462-464, 479
Russula 337, 391, 396, 464-465, 503
  aeruginea 465, 503
  fragilis 465
  puellaris 465
  subfoetens 403, 464
  velenovskyi 404, 465
  vesca 465

Sagenomella 239, 243
  striatispora 243
Schizopora 385
  carneolutea 374
  flavipora 374
  paradoxa 375, 385
  radula 375
Scleroderma 390, 481-483, 490, 495
  sect. Aculeatispora 481
  arenicola 392, 397, 481-482
  bovista 392, 397, 483, 500
  citrinum 392, 396-397, 482-483
Sclerosystis
  sinuosa 11
Septoplaca
  limbata 63
Septosperma 43-48, 50-52
  anomala 43-47, 51
  anomalum 46-47, 50
  irregulare 46-47, 50-51
  irregularis 44, 46-47
  multiforma 44, 46-47
  multiforme 46-47, 50-51
  multiformis 46
  rhizophidii 43-47
  rhizophidiii 46
  rhizophydii 43, 46-48, 50-52
  spinosa 44-47
  spinosum 46-47, 50-51
Siphonaria 51
Sistotrema 377, 451
  brinkmannii 375-377, 385-386
  oblongisporum 376-377, 386
Sistotremastrum
  niveocremeum 377
Skyttea 285, 295
  elachistophora 285
Solorina 289
Sphaerellothecium 273, 286
  abditum 286-288
  contextum 286-287
  subtile 263, 286, **287**-288
Sphinctrina 294
  anglica 288
  tubaeformis 288
  turbinata 288
Sporastatia 283
  asiatica 283
  polyspora 283
  testudinea 283, 286-287
Steccherinum 385
  bourdotii 378
  ochraceum 378
Stigmidium
  atryneae 289
  congestum 263, 289-**290**
  fuscatae 290
  glebarum 291
  psorae 291
  schaereri 289-290
  tabacinae 291
Strigula
  nitidula 167
Strobilomyces 495
  floccopus 392, 394, 400-401, 411
Strossmayeria 332
  viridi-atra 327, 331
Suillus 339, 343, 390-391, 414, 416, 426-427, 486, 494-495, 502-503
  sect. Glandulosi 495
  sect. Larigni 495
  sect. Solidipedes 495
  subsect. Spectabiles 495
  aeruginascens 427
  albidipes 420-421, 502
  americanus 397, 414
  brevipes 394, 398, 415-416
  glandulosus 396, 398, 416-417, 422, 494
  granulatus 397, 417-418, 421, 426, 498
  grevillei 394, 397-398, 418-419
  luteus 394, 398, 419-420, 498
  neoalbidipes 394, 398, 420-421, 502
  ochraceoroseus 397, 421, 494
  pictus 423, 502
  sinuspaulianus 398, 417, 422, 494
  spectabilis 397, 422, 494
  spraguei 398, 423
  subluteus 398, 416, 424
  tomentosus 394, 397, 424, 426
  umbonatus 394, 397-398, 414, 426-427
  variegatus 426
  viscidus 398, 427, 494
Systremmopsis 68

Tapellaria
  epiphylla 167
Teloschistes 278, 284
  chrysophthalmus 278, 284-285, 287-288
Tephromela
  armeniaca 252, 274, 287
  atra 285-286
Terfezia 204
  arenaria 211
  berberiodora 213, 236
  magnusii 202
  oligosperma 213, 236
Thamnogalla
  crombiei 291

Thamnolia 291
  subuliformis 292
Thelephora 396, 497
  terrestris 392, 394, 399, 401, 478, 500
Thelotrema
  wightii 167
Thyridaria
  rubro-notata 118
Toninia 291
  caeruleonigricans 291
  candida 291
  tristis 291
Torula
  herbarum 317
Trabutia 101
Trametes
  versicolor 422
Trapeliopsis 252
  granulosa 284-285
Tricellula 306
  curvatis 306
  graminis 298
Trichaptum 380
  abietinum 378
Trichia
  floriformis 17, 21
Tricholoma 390-391, 431, 441 , 494, 502
  subg. Tricholoma 390, 441, 494, 502
  sect. Albidogrisea 502
  sect. Genuina 390, 441, 494
  sect. Tricholoma 390, 441, 494
  albobrunneum 403-404, 441
  aurantium 402, 404, 442
  cingulatum 403-404, 441-442
  flavobrunneum 444
  focale 403-404, 443-444
  fulvum 391, 403-404, 444-445, 500
  imbricatum 403-404, 445, 449, 502
  myomyces 401-404, 441, 445
  pessundatum 401, 403, 446
  populinum 403-404, 447, 503
  resplendens 394, 401-403, 448
  vaccinum 403-404, 445, 448-449, 502
  virgatum 404, 449-450
Truncocolumella 339, 343, 345, 495
  crinita 339, 343, 394, 398, 490
  rubra 339, 343
Tuber 161, 171-175, 237, 396
  aestivum 171-179, 213-215
  albidum 213
  asa 201, 211-213
  borchii 213
  brumale 171
  excavatum 213-216
  ferrugineum 219
  foetidum 213
  malenconii 214, 237
  melanosporum 171, 173
  mesentericum 171-174, 176-179, 214
  nitidum 201, 215-216, 219
  oligospermum 213, 238
  panniferum 201, 216-217
  puberulum 237
  rufum 216, 218-219
  uncinatum 171, 214
Tubulicrinis 385
  borealis 380-381
  gracillimus 379-380, 383
  strangulatus 380-381
Tuckermannopsis 278
  pinastri 265
Tympanis 330, 332

Umbilicaria 87
Upsylon 298-299

Volucrispora 298-299
  aurantiaca 306
  graminea 297-302, 306
  ornithomorpha 306
Vouauxiomyces 294
  truncatus 292
Vuilleminia 384
  comedens 381
  cystidiata 381-382

Wettsteinina 104

Xanthoconium 503
Xanthomaculina 86
Xanthoparmelia 264, 269
  shebaiensis 164
  somloensis 264
Xanthopeltis 270, 295
Xanthoria 270, 277-278
  elegans 277, 283
Xenasmatella 385
  decipiens 373
Xerocomus 390, 428, 486
  badius 392, 398, 428, 502
  illudens 502
  subtomentosus 396, 398, 429
Xylogone 197

Yukonia
  caricis 353

Zahlbrucknerella 294

Zelleromyces 238, 337, 491, 495
  gilkeyae 402, 490-491
  stephensii 230-231
Zygnnella
  pygmaea 328
Zymonema 197, 199

ERRATA, VOLUME THIRTY-FIVE

Page	423	line	27	*for*	endococcinoides	*read*	endococcinodes
	432		24-28	*for*	Ceraterium	*read*	Craterium

ERRATA, VOLUME THIRTY-SEVEN

Page	79,	line	7	for	*hesperidearum*	read	*hesperidiorum*
	91		27	*for*	(Nees: Fries)	*read*	(Fries: Fries
	92		25	for	*hesperidearum*	read	*hesperidiorum*
	94		12, 29, 45		"		"
	95		legend		"		"
	96		5, 27		"		"

ERRATA, VOLUME, THIRTY-EIGHT

Page	44	line	17	for	*rubronudum*	read	*rubronodum*
	177		12	*for*	Xanthocrous	*read*	Xanthochrous

ERRATA, VOLUME FORTY

Page	5	line	12	*delete*	2249, 2255, 2285		
	10		20	*for*	1612	*read*	2612

ERRATA, VOLUME FORTY-TWO

Page	522	*add*	Heterodermia comosa	166
	526	*add*	Phylloporis phyllogena	167

REVIEWERS, VOLUME FORTY-TWO

The Editors express their appreciation to the following individuals who have, prior to acceptance for publication, reviewed one or more of the papers appearing in this volume:

J. Alcorn
T. Baroni
D. Barr
M. E. Barr Bigelow
J. Boidin
I. M. Brodo
J. L. Carne
M. Castellano
E. Descals
M. W. Dick
H. Dörfelt
J. Elix
F. Esteve-Raventós
J. Ginns
D. A. Glawe
N. Hallenberg
T. Johnson
H. W. Keller
R. P. Korf
R. E. Koske
G. Morgan-Jones
D. Nicolson
T. Niemelä
S. Redhead
G. S. Ridley
R. Santesson
B. Sutton
J. Taylor
H. Thiers
J. M. Trappe
C. M. Wetmore
M. A. Williams

PUBLICATION DATE VOLUME 41(2)

Mycotaxon 41(2) was issued on September 19, 1991

[Contents continued from inside front cover]

Book Reviews. . . . . **L. M. Kohn** 505
NOTICE: Second Regional Conference. African Mycol. Assoc.& IMA 511
Instructions to Authors 512
Author Index. 514
Index to fungous and lichen taxa. 517
Errata. 531
Reviewers. 532
Publication Date Volume 41(2). 532

EDITORS OF MYCOTAXON

JEAN BOISE CARGILL, *Editor-in-Chief*
Harvard University Herbaria
22 Divinity Avenue, Cambridge, MA 02138, USA

ASSOCIATE EDITORS

ROBERT DIRIG
Index Editor
Bailey Hortorium, Mann Library
Cornell Univ., Ithaca, NY 14853
USA

G. L. HENNEBERT
French Language Editor
UCL, Place Croix du Sud 3
B-1348 Louvain-la-Neuve
Belgium

LINDA M. KOHN
Book Review Editor
Botany Dept., Univ. of Toronto
Mississauga, Ont. L5L 1C6
Canada

MYCOTAXON is a quarterly journal devoted to all phases of mycological and lichenological taxonomy and nomenclature. It seeks to publish all papers within 5 months of submission, using photo-offset lithography. All articles are reviewed by specialists prior to acceptance. Publication is open to all persons. Papers may be in French or in English. Summaries in those or in any additional languages desired by the authors are given for longer articles. KEYWORDS are provided for each article to facilitate library and computerized access. Printing is on high quality, acid-free, recycled book paper.

EDITORIAL SERVICES & INFORMATION FOR PROSPECTIVE AUTHORS

Authors prepare their own *camera-ready* copy after having received critical comments from pre-submission reviewers. Detailed *Revised Instructions to Authors* appeared in MYCOTAXON **26:** 497-510 (1986). A copy of these instructions will be sent upon request to the Editor-in-Chief.

Neither *BIOPLATE* transfer letters nor *SPECIAL MANUSCRIPT PAPER* are any longer available, and will not be restocked unless there is a strong demand from our authors.

SUBSCRIPTION INFORMATION

Each volume, beginning with volume 3, contains at least 512 pages, and consists of an *irregular* number of quarterly issues (rarely an *additional* issue, a Festschrift, may also be included in a volume). Each issue of MYCOTAXON varies in number of pages. Subscriptions are normally on a *per volume* basis, but subscribers may choose an *annual* basis to avoid frequent billing. Currently this would involve prepaying three volumes. *Personal subscriptions* are available at a substantially reduced rate for *individuals* who agree not to deposit their copies in another library than their personal one within 3 years of receipt. Address orders to the Mycotaxon Order Department, *not* to the Editors. Prices for the current volume are:

	USA	Canada/Mexico	Other Foreign (Air)
REGULAR (multiuser)	$60.00	$62.00 US	$65.00 US
PERSONAL (individual)	$28.00	$30.00 US	$35.00 US

(*All back volumes are still available.* Volumes 1 through the latest *complete* volume are available at $25.00 per volume when shipped by *surface mail*, $40 per volume by *air mail*.)

Place subscriptions through the Order Dept., MYCOTAXON, LTD., P.O. Box 264, Ithaca, NY 14851-0264, U.S.A. or through your agent. MYCOTAXON may also be obtained on a journal-exchange basis. This may be arranged with journals, institutions, or individuals who have difficulty in obtaining foreign currency.

TWENTY-VOLUME CUMULATIVE INDICES, 1974-1984, & 1984-1991

MYCOTAXON CUMULATIVE INDEX FOR VOLUMES I-XX (1974-1984) by Richard P. Korf & Susan C. Gruff (ISBN 0-930845-00-5) is available at $17.50 *postpaid*, and MYCOTAXON CUMULATIVE INDEX FOR VOLUMES XXI-XL (1984-1991) by Richard P. Korf & Susan C. Gruff (ISBN 0-930845-01-3) is available at $30.00 *postpaid*, from MYCOTAXON, LTD., P.O. Box 264, Ithaca, NY 14851-0264, U.S.A.

AVAILABILITY IN MICROFORM, TEAR SHEET, & PHOTOCOPY

MYCOTAXON is also available in *microfiche* and in *microfilm* from University Microfilms, 300 North Zeeb Road, Ann Arbor, MI 48106, U.S.A., or 30-32 Mortimer Street, London W1N 7RA, England, from whom prices may be obtained.

Tear sheets or photocopies of individual articles may be obtained through *The Genuine Article*™, I.S.I., 3501 Market Street, Philadelphia, PA 19104, U.S.A., from whom prices may be obtained.

CONTACTING MYCOTAXON'S EDITOR-IN-CHIEF BY E-MAIL OR BY FAX

To reach the Editor-in-Chief regarding manuscripts, you may use this electronic mail INTERNET address: Cargill@HUH.Harvard.Edu. or you may FAX to Jean Cargill at (617) 495-9484.

CONTACTING MYCOTAXON'S ORDER DEPARTMENT BY E-MAIL OR BY FAX

To reach the Order Department for information or placing orders, you may use this electronic mail BITNET address: MYC @ CORNELLA, or you may FAX to Richard Korf at (607) 255-4471.